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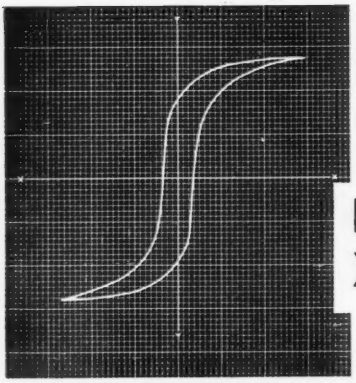

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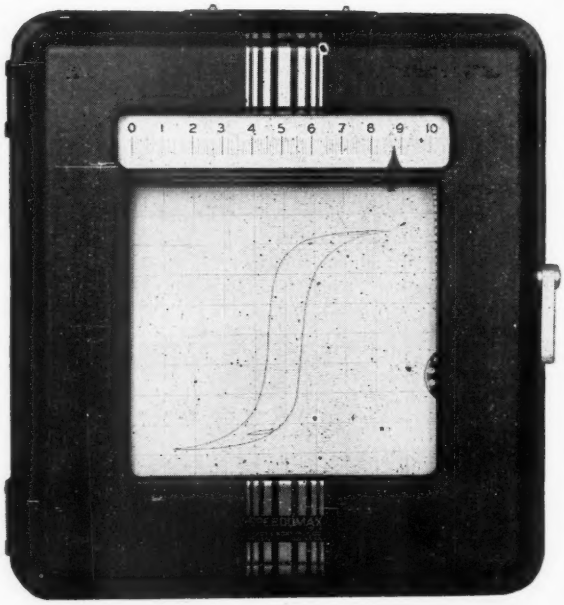

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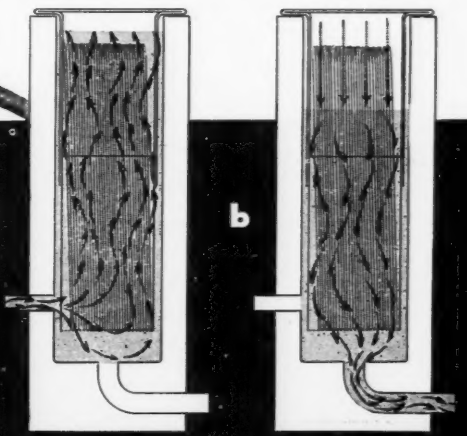

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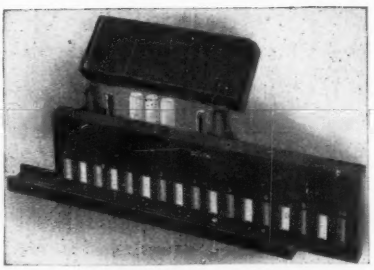

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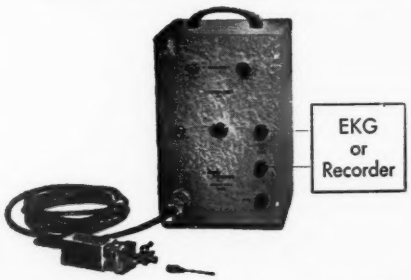

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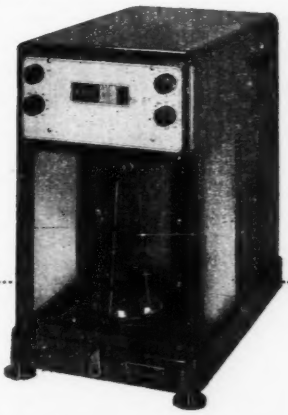

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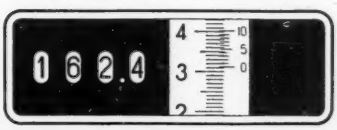

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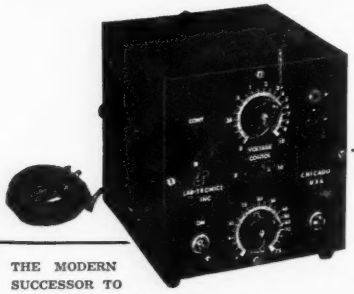

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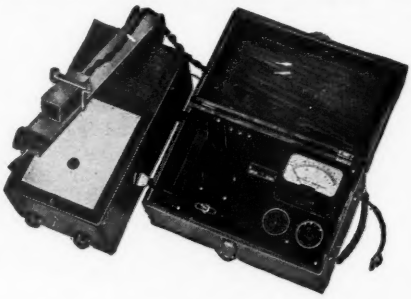

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E. J. Lofgren

Radiation Laboratory, University of California, Berkeley

IN 1910 AND 1911 Geiger and Marsden performed a series of experiments designed to reveal something of the structure of the atom. They directed a collimated beam of alpha particles through a thin gold foil and observed the distribution in direction of the emerging particles. Although most of the particles were scattered through small angles they found that some suffered very large deflections—indeed, about 0.01 percent of them were deflected through angles greater than 90°. This was completely inconsistent with any kind of continuous structure of the atom—as, for example, a homogenous distribution of positive charge with imbedded electrons. Rutherford proposed a very different model, in which the positive charge and most of the mass were concentrated in a central sphere one ten-thousandth the radius of the whole atom. Occasional close collisions of the impinging alpha particles with this central nucleus would result in large deflections, and it was thus possible to explain quantitatively the experiments of Geiger and Marsden. This was the beginning of our modern theories of atomic and nuclear structure. Since that time and especially since 1930, a large part of nuclear physics has consisted of further probing of the nucleus with beams of various particles to reveal its structure and properties. However, even an outline of the developing ideas of nuclear physics is beyond the scope of this article, which is concerned only with the means of providing the probing particles.

Naturally occurring high energy particles (except for cosmic rays) are limited to the alpha and beta particles of radioactive substances whose energies are a few million electron volts. As nuclear experiments continued, higher energies and more kinds of particles were needed. Experimenters also found they were hindered by their limited control over the direction, intensity, and energy of natural particles. To fill these needs, a series of particle accelerators were developed, as outlined in Table 1. Development of the first three was carried to the point of successful application to nuclear physics in the early 1930's. The betatron dates from 1940. The next three became useful machines in 1946, 1947, and 1948. All of these machines are still being developed and with their varying energy ranges, intensities, suitability to different particles, and degrees of control, each one

TABLE 1

Accelerator	Particle*	Highest energy of operating equipment in Mev†	Highest energy of equipment under construction in Mev	Remarks
Electrostatic accelerator	Any charged particle	5	12	Capable of precise energy control and collimation. Limited to the lower energy range because voltage is applied in one step.
Rectifiers or transformers	Any charged particle	2		Similar to the electrostatic accelerator.
Cyclotron	p d α	10 20 40	30	A reliable and economical accelerator in the medium energy range. Limited to energies of a few 10's of Mev by the relativistic mass increase.
Betatron	e	100	300	For electrons only. A simple machine in the medium energy range but limited by radiation loss to several hundred Mev.
Synchrocyclotron	p d α	350 190 380	450	This machine overcomes the energy limitation of cyclotron but becomes uneconomical above 500 Mev. Beam intensity is lower.
Linear accelerator	p e	32 25	66 1,000	The energy is unlimited. It has the advantage over magnetic machines that the beam emerges in a well-collimated bundle with a small energy spread.
Synchrotron	e	335	1,000	Raises the energy limitation of the betatron.
Proton synchrotron	p	6½	3,500	The energy limit is the economic one but it is higher than that of the synchrocyclotron.

* Particles: p, proton or hydrogen nucleus; d, deuteron or heavy hydrogen nucleus; α, alpha particle or helium nucleus; e, electron.

† Mev, 10^6 electron volts.

supplements rather than replaces its predecessors.

As increasing effort has been made to understand the nature of cosmic rays they have been revealed as a rich source of particles useful for nuclear investigation. These observations have already yielded the positive electron and a growing family of mesons, and have provided the experimental background to a number of advances in electrodynamic theory. Cosmic ray particles may have energies up to 10^{16} electron volts, assuming that extensive Auger showers are initiated by a single primary particle. They strike the earth's atmosphere at a rate of about 0.6 per cm² per second, and consist chiefly of protons, although it has recently been shown that a few percent of them are nuclei of various atoms up to at least the middle of the table of elements, with the possibility that all nuclear species are present. As the particles pass through the atmosphere they interact with atmospheric nuclei, sharing their energy with existing particles and creating new ones. Cosmic radiation below the top of the atmosphere is therefore an exceedingly complicated mixture of interrelated particles and quanta. It is desirable, in the energy range where it can be done, to supplement cosmic rays with laboratory-produced radiation so that conditions can be controlled and simplified. The artificial source can also have much greater local intensity. It is here that the proton synchrotron fits into the scheme of things. Projected machines are in the range 1 to 6 Bev (billion electron volts). The average energy of primary cosmic ray particles is 10 Bev; thus the lower range of cosmic ray energies is nicely covered, but the upper range to 10^{16} electron volts is a million times higher than that which will be reached by accelerators now being built.

A limitation is imposed upon cyclotron energies by the particles' relativistic increase of mass as they are accelerated. This can be readily seen as follows. An ion in a uniform constant magnetic field of B gauss describes a circular path of r cm radius such that

$$Br = \frac{v}{e/m}$$

where $\frac{e}{m}$ is the charge-to-mass ratio of the ions and v is the velocity. From this we can write for the time per revolution,

$$t = \frac{2\pi}{e/m\,B}$$

This is essentially a constant in the nonrelativistic range; hence an alternating electron field of frequency $1/t$ applied to a diametrical accelerating gap will give an incremental acceleration each revolution to ions starting in the proper phase. However, the mass changes with the velocity according to the relationship $m = \frac{m_0}{\sqrt{1-\beta^2}}$, where m_0 is the mass of the ion at rest and β is the ratio of the velocity of the particle to that of light. If then the particle is accelerated until its velocity is half the velocity of light (the energy of a proton with this velocity would be 150 Mev), the mass is 15 percent greater than the rest mass and the time t is 15 percent greater than for the first turn. Under these conditions the ions would get out of phase with the accelerating field and would not be accelerated.

The theory of the synchrotron—electron or proton—and the synchrocyclotron which circumvented this difficulty was worked out independently by V. Veksler (*11*), E. M. McMillan (*6*) and M. L. Oliphant (*7*) and depends upon the phase stability of an ion in a magnetic field under certain conditions. Suppose that we have an ion in the extreme relativistic energy range pursuing a circular path of radius r in a uniform magnetic field, and that we apply a voltage of the proper radiofrequency as before, but suppose it to be of such phase that the voltage goes through zero as the ion crosses the accelerating gap and that an earlier crossing of gap will result in acceleration.

The radius is given by:

$$r = (E^2 - E_r^2)^{\frac{1}{2}}/300\,B$$

(*6*), where E is the total energy $= E_k + E_r$,

E_r is the rest energy = 935 Mev for proton,

E_k is the kinetic energy.

The expression may then be rewritten in the form

$$r = (E_k^2 + 2E_kE_r)^{\frac{1}{2}}/300\,B.$$

If E_k is large compared to E_r

$$r = E_k/300\,B, \text{ approximately.}$$

Thus in the relativistic range the radius is proportional to the energy and the velocity approaches the constant velocity of light. Earlier arrival at the gap results then in greater energy and a longer circular path but little change in velocity and hence the particle will be later in crossing the accelerating gap the next time. Conversely if it were to arrive too late it would be decelerated, pursue a shorter path, and catch up in time. The particle, if disturbed in phase, then oscillates about the stable phase, where it gains no energy in crossing the gap. These arguments for stability of phase are not valid at low energy but the same kind of stability can be achieved by having the magnetic field decrease radially. This is desirable anyway, to keep the ions in the median plane of the magnetic field. If the magnetic field or the frequency of the accelerating field or both are slowly changed in the proper direction the energy of the particle will increase and the stability will hold for the phase such that just enough energy is gained during each revolution to keep step with the changing field or frequency. In addition to the phase oscillation, which is slow compared to the rotational fre-

quency, there are also radial and vertical oscillations in position, comparable with the rotational frequency. They are known as the betatron oscillations.

Several different accelerators have been devised on the basis of the principle of phase stability. The distinction between them depends upon which parameters are varied. In the case of electrons no change of frequency of the accelerating field is required if the particles are given 2 Mev or a little over by some other means because they then have 98 percent of their limiting velocity. The magnetic field is increased with time to hold the orbit radius constant. The vacuum tank is toroidal and the magnetic field fills an annular space. This machine is a synchrotron. There are two possibilities in the case of heavy ion acceleration. In the first the magnetic field is constant and has the same configuration as for a cyclotron. The ion source at the center and the accelerating dee is also the same but the frequency of the accelerating voltage decreases as the mass of the ions increases and their period of revolution increases. The orbit radius increases so that the total path is a close-pitched spiral. This machine is a synchrocyclotron. As accelerators of this type are made larger an economic limit is approached at 500 to 1000 Mev, chiefly because of the very large magnet structure required. The remaining possibility is that the magnetic field as well as the frequency should vary. The orbit radius can then be held constant, requiring only an annular magnet, which is very much cheaper than the corresponding cyclotron type of magnet. Three of these proton synchrotons are being built at present. One, at the University of Birmingham, England, is designed for 1.3 Bev. Another, under construction at the Brookhaven National Laboratory, will accelerate protons to about 3 Bev and is called a cosmotron. A third is building at Berkeley and will initially operate at 3½ Bev but it can be modified to produce protons of about 6 Bev. This machine has been named a bevatron. The only physical limit to the energy of this class of accelerator is that imposed by the loss of energy due to the electromagnetic radiation from a charged particle moving in a circular path. For protons, this limit is so high that the cost, which is one to two million dollars per Bev, is the governing limitation. The theory of the proton synchrotron is given in detail in references *3* and *10* and proposals for their construction are outlined in *1* and *7*.

The basic design of the Berkeley bevatron stems from the proposals of W. M. Brobeck (*1*). The magnet will consist of four 90° annular segments spaced so that the ion orbits are quarter-circles connected by straight sections. That magnet arrangement was first proposed by H. R. Crane (*2*) for a synchrotron he is now building. Provision is made in the straight sections of the vacuum tank, between the magnet segments, for evacuating the tank, injecting the beam, placing the accelerating electrode, and performing experiments with the beam. Magnet power will be provided by a motor generator with a large flywheel. During build-up of the magnetic field, energy will be drawn from the flywheel and stored in the magnet. As the field is reduced the generator acts as a motor and returns energy to the flywheel. The motor makes up only the losses, which for each pulse amount to 40 percent of the stored energy. It is intended that the protons will be injected at 10 Mev from a linear accelerator. Some of the dimensions, as finally settled upon, are given in the first column of Table 2.

TABLE 2

	Bevatron now being constructed	¼ Scale model now completed
Proton energy	3⅔ Bev	6½ Mev
Number of protons per pulse	10^{10} or more	$2 \cdot 10^8$
Pulse rate	10 per minute	18 per minute
Orbit radius	48½ feet	11½ feet
Length of straight sections	20 feet	5 feet
Cross sectional aperture of useful magnetic field: vertical	24 inches	9.5 inches
Cross sectional aperture of useful magnetic field: radial	72 inches	36 inches
Number of revolutions during acceleration: vertical field	$3.8 \cdot 10^6$	$0.9 \cdot 10^6$
Number of revolutions during acceleration: radial field		
Distance traveled during acceleration	270,000 miles	15,000 miles
Acceleration time	1.75 second	0.25 second
Maximum magnetic field	9,800 gauss	1,000 gauss
Magnet weight	10,000 tons	150 tons
Energy stored in magnet	$8.3 \cdot 10^7$ joules	$4 \cdot 10^4$ joules
Magnet operating power	6,000 kilowatts	30 kilowatts
Acceleration radiofrequency	0.37 to 2.5 megacycles	0.4 to 1.2 megacycles
Injection energy	10 Mev	0.7 Mev

Before the design entered the final stage there was some uncertainty as to whether or not the theory could be trusted in detail. In particular, no machine had yet run with straight sections as proposed by Crane, and it was conceivable that an unforeseen perturbation would introduce ion oscillations large enough to drive the beam into the tank walls. There was also the very important question as to just what would be a reasonable cross section for the useful magnetic field. Obviously, there are conflicting factors. With a given investment in magnet and excitation equipment one could have a small aperture with high field, which would give high energy particles but would permit only very limited deviation from ideal ion orbits. On the other hand, choosing a large aperture would lower the final energy. Turning the in-

jected ions into their orbit requires some kind of electrodes that extend into the tank, and many of the ions on subsequent turns will be intercepted by this structure. We were not sure what fraction could be made to escape this fate.

To answer questions such as these and to provide general operational experience it was decided to build a working model on ¼ linear scale. Since nearly all of the things that might go wrong should occur soon after injection, about 6-Mev acceleration was considered sufficient. This, of course, made the model very much cheaper in terms of magnet and excitation equipment. The second column of Table 2 gives the essential dimensions of the model.

The general structure is shown in Fig. 1. To decrease eddy current effects the magnet structure is made of ½-inch plates separated by paper insulation, and for the same reason the vacuum tank is made of 1/32-inch stainless steel in sections about 1 foot long, each section sealed to the others but insulated from them by rubber gaskets. The atmospheric load on the tank is transmitted by attachment bars to the magnet yoke. Fig. 2 is an over-all view, with the injector cyclotron in the foreground.

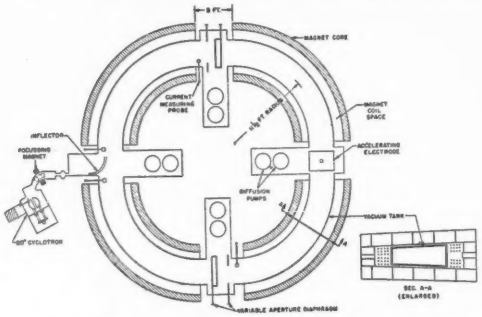

FIG. 1. Diagram of the ¼-scale operating model bevatron.

The protons are accelerated to 0.7 Mev in a cyclotron which operates for one millisecond and is triggered by the bevatron magnet current as it reaches the proper value. The ions pass through a focusing magnet and then as they enter the bevatron magnet they are turned by the electric field of the inflector electrodes so that they are tangent to their bevatron orbit. As the magnetic field increases, but with no energy added to the ions, they oscillate about circular paths of decreasing radius. Before they all reach the inner tank wall the accelerating electrode is excited with a frequency equal to the rotational frequency. This electrode is in the straight tank section opposite the inflector and is an open-ended copper tube placed so that the ions go through it. The energy given to the protons is equal to the change in voltage on the electrode during the traversal, since the electric fields at the two ends are opposite in direction. In the model bevatron the protons are given about 40 electron volts per turn to keep step

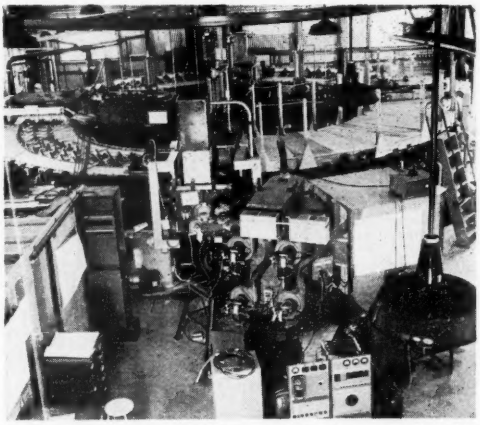

FIG. 2. Photograph of the model bevatron showing the injector cyclotron in the foreground.

with a magnetic field increasing at 4000 gauss per second. Since the ions are well out of the relativistic range the velocity and hence the rotational frequency is proportional to the momentum of the particles. The momentum of a particle at constant radius is proportional to the magnetic field; hence the applied radiofrequency must vary as the magnetic field. This variation in frequency is accomplished by passing a portion of the magnet current around the ferromagnetic core of the inductance in the radiofrequency circuit. The increasing saturation of the core as the magnet current increases lowers the inductance and increases the frequency of the circuit.

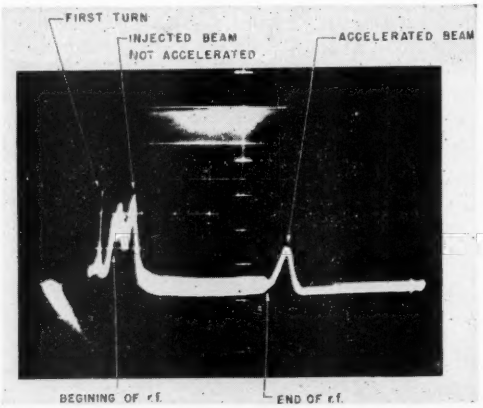

FIG. 3. Oscilloscope trace of bevatron beam. Horizontal divisions are 2 milliseconds; vertical divisions are 0.8×10^{-5} amperes.

The required frequency range is from 0.4 to 1.2 megacycles per second. In about one quarter of a second the magnetic field has nearly reached its limiting value of 1000 gauss and the protons have an energy of about 6½ Mev. The radiofrequency is cut off, a further small increase of magnetic field decreases the orbit radius, and the ions are intercepted on a probe introduced through the inside wall of the annular tank. The oscilloscope trace, Fig. 3, shows

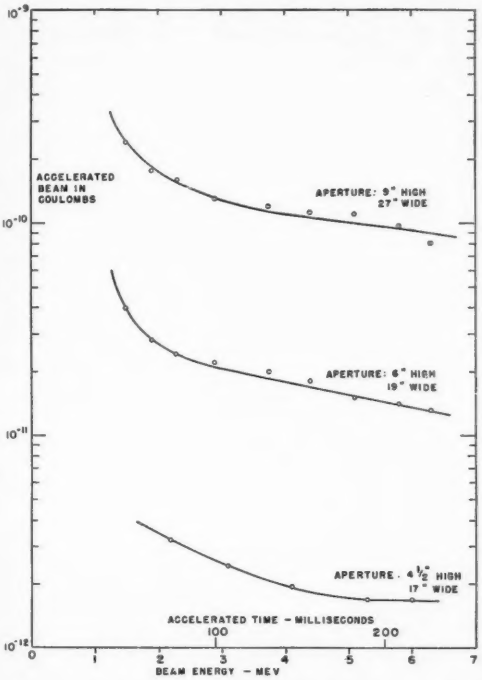

FIG. 4. The beam as a function of final energy for three tank apertures.

the history of a single pulse; in this case the acceleration lasts for only 10 milliseconds so that the entire pattern can be shown. Ions of the wrong energy or direction hit the probe on the first turn. Of the surviving ions, those that cross the accelerating electrode in the right phase are accelerated. Those in the wrong phase are driven into the probe immediately after the radiofrequency is turned on.

In their long path in the bevatron the ions suffer many collisions with the residual air molecules in the tank. Note from Table 2 that the ions in the bevatron and the model are accelerated for 1.75 seconds and 0.25 seconds, respectively, as compared to 0.002 seconds in the 184-inch synchrocyclotron. The combined effect of many such collisions during this long acceleration, particularly just after injection when the energy is low, causes a substantial loss of beam. We found that an increase of pressure of 1.7×10^{-6} mm Hg resulted in a decrease of the beam by a factor of $1/e$. This agreed with the expected loss within the accuracy of the theory and the measurements. The usual operating pressure was 2×10^{-6} mm. The decreasing loss of beam at greater energies is shown in Fig. 4. Here the final energy is adjusted by changing the duration of the accelerating radiofrequency pulse and recording the integrated beam picked up on a probe with a constant injected pulse. Most of the loss occurs at energies less than 3 Mev. Using the adjustable aperture diaphragms provided in two of the straight tank sections, these data were taken for three cross sections. The middle curve most nearly corresponds in relative size to the 24-inch-high, 72-inch-wide aperture chosen for the full-size bevatron.

The betatron oscillations of the ions in the radial and axial directions are approximately given[1] by

$$f_r = \sqrt{1-n} f_0$$

$$f_a = \sqrt{n}\, f_0$$

where n expresses the radial decrease of the magnetic field $n = \frac{r}{B}\frac{dB}{dr}$ and where f_0 is the rotational frequency. The constant, n, equals 0.6; hence both frequencies are near to the rotational frequency. It is very important that there be no simple harmonic relation between these frequencies. If there were, the amplitude of one of the oscillations might build up until the ions were lost to the tank walls. These frequencies were measured by an experiment suggested by H. R. Crane, in which a radiofrequency field is established in a radial or axial direction across the vacuum tank. At the proper frequency it will increase the oscillations and destroy the beam. The calculated frequencies were verified to about 1 percent.

Some things of interest were learned which are not yet quantitatively explained. Two of these effects apply to the critical period of injection. It was

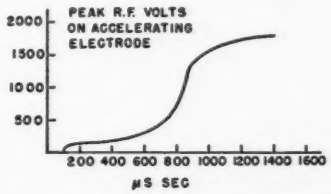

FIG. 5. Optimum shape of radiofrequency rise time curve.

found that if the accelerating radiofrequency voltage was applied as shown in Fig. 5, rather than with a

[1] The accurate expressions are complicated by the effect of the straight sections of which these expressions take no account.

linear rise or an abrupt step, the beam was increased by 75 percent. There was also an increase of about 100 percent if the voltage on the inflector electrode was removed immediately after injection.

The largest beam with the bevatron aperture set at 6 in. × 18 in. was 3.5×10^{-11} coulombs per pulse (or about 2×10^{8} protons per pulse). The injected beam measured at the end of the inflector electrodes was 10^{-8} coulombs. The over-all particle efficiency of the machine then was about ½ percent. In the full-scale bevatron the losses due to gas scattering should be negligible because of the higher injection energy. In addition, while the tank height is scaled up by a factor of four the size of the inflector electrodes need not go up at all, so that ions will have a greater chance of missing the inflector after injection. It is therefore reasonable to expect a particle efficiency of at least several percent in the full-scale bevatron.

The bevatron development at the Radiation Laboratory is sponsored by the Atomic Energy Commission. It is under the direction of E. O. Lawrence and involves the work of many people. W. M. Brobeck is responsible for the basic design. Major responsibilities are also carried by those listed as authors in references *4, 5, 8,* and *9*. R. S. Shankland, of the Case Institute, and F. H. Schmidt, of the University of Washington, carried out some of the experimental measurements on the ¼-scale model.

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The Comparative Biochemistry of Vitamin Function

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PLANNED STUDIES of comparative biochemistry and comparative physiology are few as compared with the voluminous data on comparative morphology. The trend of recent years in the biological sciences away from the descriptive and toward the functional viewpoint, however, has evoked increased interest and study of the comparative approach. This has for the most part centered around the more gross aspects of nutrition and metabolism. Simultaneously, there has been an increased appreciation of the values to be gained from the study of some particular functional entity throughout a range of species, such that comparative biochemistry may well dominate the next developmental phase of biological science.

The history of the discovery of vitamins and elucidation of the vitamin concept has drawn heavily upon interspecies relationships. Williams' (*6*) discovery in 1919 that the antiberiberi substance was probably identical with a microbiological growth factor opened up a point of view that has permitted rapid exploitation of the vitamin field. Parallel studies in highly dissimilar species have characterized much of the work with the B vitamins from their discovery until the very present (*3, 4*), and indeed this group is characterized by the ubiquitous biological nature of its occurrence (*11*). Consequently, there exists in the literature a large amount of data of such a nature as to render much of it suitable for examination from the comparative approach. It therefore seems timely to consider what principles may be derived from a consideration of these data.

Chemical structure, natural distribution, and physiological activity of the vitamins. A variety of factors tends to strengthen the validity of grouping the vitamins into three categories: the B vitamins, the fat-soluble vitamins, and vitamin C.

The B vitamins are characterized by a ubiquitous biological distribution, and have a wide variety of structures. Naturally occurring analogues essentially involve modifications only in functional groups. Other vitamins are not ubiquitous, and if vitamin C is ex-

cluded, those remaining—vitamins A, D, E, and K—are seen to share the common properties of being structurally related to isoprene polymers. Their homologues have carbon chain modifications, and have a high species specificity in biological activity and occurrence (*10*). Among the higher species in which these vitamins are active, B vitamin homologues generally have little or no species specificity in activity. They do show a species specificity in distribution in a broad sense, pyridoxine and niacin predominating in the plant kingdom, and pyridoxal, pyridoxamine, and nicotinamide predominating in animals. B vitamin homologues frequently manifest great differences in biological activity among bacterial species.

The vitamin requirements of various animal species. Early in the study of vitamin B_1 it was pointed out that the vitamin B_1 requirement on a weight basis was larger for smaller animals (*2*), and this fact was easily associable with the fact that smaller animals have a higher basal metabolic rate (*1*). The species size relationship to metabolic rate is the observation upon which much of the present knowledge of comparative biochemistry is based, and it might logically be expected that more vitamin B_1 would be required to lubricate the more highly geared machinery of smaller species. Despite the importance of this relationship, no apparent effort has ever been made to apply it to the other vitamins until quite recently, when it was shown that the same relationship seems to hold, as far as existing data permit its assessment, for the other B vitamins (*9*). As in all such relationships, apparent species exceptions occur, but these are never such as to invalidate the general trend. By contrast, it has been recognized for some time that the vitamin A requirement is approximately the same on a weight basis for all species studied (*5*), and the limited data available on the requirements for vitamins C, D, E, and K suggest strongly that a similar consideration holds for them. These facts seem to indicate that, whereas the B vitamins function in fundamental roles in metabolism, as we now know that they do in most cases, the other vitamins have specialized functions not critically related to the basal metabolism. This conclusion is strongly supported by the apparent absence of these other vitamins from most microbial forms. The classification of both groups of substances under the single generic term of *vitamin* may frequently be misleading, because of the implication that they constitute a single fundamental functional group. From the purely biochemical standpoint, the groups have little or nothing in common.

Blood levels of vitamins in various species. At high levels of vitamin intake, the blood level seems to indicate little more than the differential between the rate at which the vitamin enters the blood and the rate at which it leaves via excretory channels. At more moderate dietary levels, however, the blood level is probably an indication of the amount necessary to maintain an equilibrium with the required amounts in the

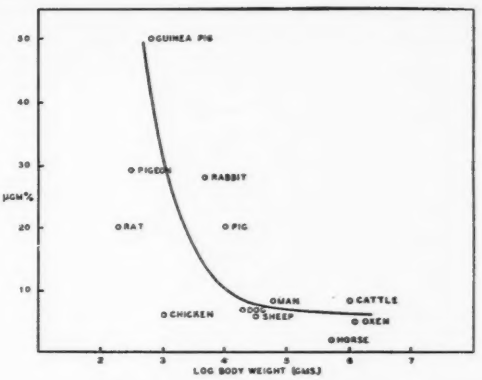

FIG. 1. Total thiamine in blood.

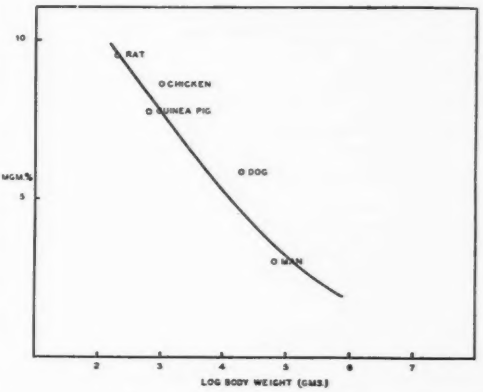

FIG. 2. Coenzyme I in blood.

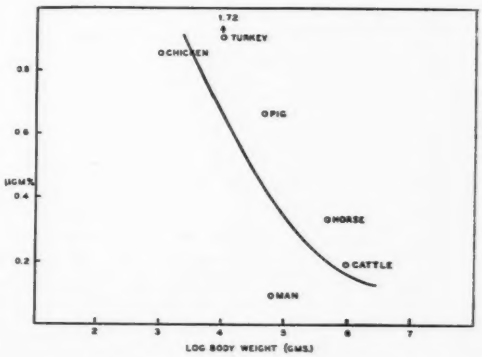

FIG. 3. Free folic acid in blood.

tissues. If animals that have higher requirements also have higher tissue levels, it might be expected then that they would have higher blood levels. Sufficient data are available for thiamine, niacin, and folic acid to indicate that this is so (Figs. 1–3). A limited amount of data for the other B vitamins suggests similarly that smaller species have higher blood levels. Although considerable data are available for vitamins A, C, D, and E, they show little relationship to species size or to ecological factors. It would thus seem again that the B vitamins are distinguished from the other vitamins by the fact that smaller animal species tend to have higher blood levels. Moreover, the B vitamins and vitamin C in blood are most generally present in highest amounts in the cellular elements, whereas vitamins A, D, and E are predominantly in the plasma.

Tissue levels of vitamins in various species. It has been recognized for some time that the tissues of smaller animals tend to have higher B vitamin levels than the tissues of larger animals (*7*). Whereas the voluminous data available are adequate to insure the validity of this generalization, the concept is considerably hampered by the existence of numerous deviations from this trend, which are at present unexplainable. From a theoretical standpoint it seems entirely reasonable to expect that animals having a higher metabolic rate would require higher tissue levels of vitamins than animals having a lower metabolic rate. Moreover, if the logarithm of the oxygen consumption per gram of tissue is plotted against the thiamine (or other B vitamin) content of that tissue for even such diverse things as vertebrates, tissues of vertebrates, invertebrates, green plants, and bacteria, it is apparent that there is a definite correlation between the two factors. It is also apparent that when these factors are considered, the species fall into three major categories; the cold-blooded animals and green plants, which contain about 10 micrograms of thiamine per gram of wet tissue for every milliliter of oxygen consumed per gram of tissue per hour; the warm-blooded animals and their tissues, which contain about 1 microgram, and the aerobic bacteria, which contain from 0.1 to 0.001 microgram per gram of packed cells. Using even such rough conversion factors as these, it is possible to calculate the thiamine content of the diverse members of the first two groups from the oxygen consumption within about 50 percent of their actual values. The differences in these groups may be almost entirely attributed to the temperature effect in the cold-blooded animals and to the greater surface area of the bacteria.

This same tendency may be examined from another standpoint—that of the time taken for a species to reach maturity. Williams *et al.* (*8*) have shown that the protein level of milk varies among species in an inverse manner with the time required to reach maturity, and that the B vitamin levels in milk from various species vary in a similar manner. This relationship is of considerable interest in that it would seemingly be impossible were the trends previously considered not also true.

A final consideration in regard to tissue levels is the fact that in any given species, the B vitamin levels in specific organs and tissues follow closely the respiratory rates of these tissues. Exceptions occur in this case, which can generally be explained on the basis of specialized functions of the tissue or organ, but the B vitamin content is a fair indication of the over-all metabolic activity of the material in question.

The tissue and milk levels of vitamins A, C, D, E, and K vary among animal species largely in relation to dietary habit. Moreover, in the tissues of any given species, concentrations follow almost entirely the specialized functions and the storage abilities of the tissues. While data are somewhat limited in this regard, it is readily apparent that relationships depending upon species size and metabolic rates do not exist.

Conclusions. On the basis of nutritional requirements, distribution, and relationship to the metabolic rate, the vitamins fall into two distinct groups. One group includes those vitamins which have been classed as B vitamins, and which show themselves in a variety of ways to be intimately associated with the fundamental metabolic apparatus of living cells. A consideration of nutritional requirements, blood levels, tissue levels, and metabolic rates shows that these vitamins are associated in increased amounts with smaller species, whereas the remainder of the vitamins manifest no such relationships and appear to have only highly specialized functions for certain tissues and cell groups. A further comparative biochemical study of this group may do much to elucidate the specific functions of its members.

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Technical Papers

Blossoming of Fruits Delayed by Maleic Hydrazide[1]

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The flowers of many fruit plants often are killed by late spring frosts, resulting in enormous losses to the industry. If flowering could be delayed 10 days or more in many instances the danger of frost would be past. Winklepleck (*5*) and Hitchcock and Zimmerman (*1*) concluded that naphthaleneacetic acid and its derivatives were promising as means for delaying blossoming, but these compounds were found by Mitchell and Cullinan (*3*) and Marth *et al.* (*2*) to injure the plants. Recently Schoene and Hoffmann (*4*) reported maleic hydrazide to be a unique growth regulant, exerting a pronounced, but temporary, inhibiting effect on plant growth.

On April 27, 1949, dilutions of 1000, 1500, 2000, and 3000 ppm of the diethanolamine salt of maleic hydrazide in water were sprayed on certain fruit plants. Unfortunately, peaches, cherries, currants, and gooseberries were already in flower and could not be tested during this season. Flowers of the Golden Delicious apple were in the early pink stage and all applications of maleic hydrazide were followed by early abscission of the fruit. No retardation of vegetative or floral development was apparent. Second year plants of Premier strawberry had many flowers formed but not open when sprayed on April 27. Although these flowers proceeded to open, one month after treatment check plants continued to blossom profusely, whereas treated plants ceased to blossom. About one week later the plants treated with 1000 ppm resumed blossoming. Vegetative development was definitely retarded, but no specific injury was apparent. Unfortunately, these plants were a part of another experiment and had to be plowed under before additional observations could be made. It seems likely, however, that early spring applications on the strawberry would delay bloom.

Two-year-old vigorous Bristol black raspberries afforded the best example of the effects of maleic hydrazide in delaying blossoming. Leaflets were expanded to about 1 cm and side branches were just beginning to appear on April 27, when plants were sprayed. The treated plants blossomed 24 to 38 days later than check plants, and matured their fruit 16 to 23 days later than check plants. Fruit set was good and no difference in size or flavor of the berries was apparent. Vegetative development was temporarily inhibited and although new canes appeared late they grew rapidly and by midsummer no vegetative differences were apparent. No injury to the foliage was associated with dilutions of 1000 and 1500 ppm, but slight burning was evident with 2000 ppm, and considerable burning with 3000 ppm.

[1] Authorized for publication on November 22, 1949, as Paper No. 1559 of the Journal Series of the Pennsylvania Agricultural Experiment Station.

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Inhibition of the Shwartzman Phenomenon by Adrenocorticotropic[1] Hormone (ACTH) from the Adenohypophysis

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In the basic experiment, the Shwartzman phenomenon (*2*) is characterized by severe hemorrhagic necrosis at the skin site prepared by an intradermal injection of a bacterial filtrate (preparatory injection) following the intravenous injection of the same or another potent bacterial filtrate (provocative injection). Although nonanaphylactic in nature, the phenomenon is due to a profound alteration in vascular reactivity. Direct and indirect clinical evidence strongly suggests that the phenomenon demonstrates the mechanism underlying the production of a variety of spontaneous diseases and syndromes of known and unknown etiology, in which vascular lesions are a predominant feature. A large number of different substances fail to suppress the phenomenon—i.e. pharmacological substances variously affecting the vascular system, such as antihistaminics, hormones, vitamins, antivitamins, proteins, amino acids, and British antilewisite. There are, however, a few notable exceptions. According to Thomas and Stetson (*3*), a single application of bromobenzene to the prepared skin site completely inhibits the phenomenon (possibly by interfering with the activation of the tissues' protease). Becker (*1*) suppressed the phenomenon by means of nitrogen mustard, benzol, and x-rays, whose individual effects on blood-forming organs and the reticulo-endothelial system are nearly identical.

In view of this consideration it seemed to be of particular interest to carry out the following studies on the effect of the adrenocorticotropic hormone upon the Shwartzman phenomenon.

The phenomenon was elicited with the meningococcus 44B "agar washings" filtrate made in the manner previ-

[1] The authors are thankful to Dr. John R. Mote, Armour Laboratories, Chicago, for supplying the adrenocorticotropic hormone for these studies.

TABLE 1

INHIBITION OF THE SHWARTZMAN PHENOMENON BY ACTH

Prepreparatory treatment			Preprovocative treatment			Reactions		
Substance	Dose	Hr prior to I.D. inj.† of bacterial filtrate	Substance*	Dose	Hr prior to I.V. inj.‡ of bacterial filtrate	Strongly positive	Doubtful	Negative
..	..	..	..	..	..	26	0	2
..	..	..	P.S.	0.5 oxytocic u. + 0.5 pressor u.	2	4	0	1
..	..	..	"	0.75 oxytocic u. + 0.75 pressor u.	1	5	0	0
..	..	..	"	"	2	6	0	0
ACTH	2×5 mg	18 and 1	..	..	..	4	0	0
"	12.5 mg	2	..	..	..	6	0	0
..	..	..	ACTH	2.5 mg	2	1	0	1
..	..	..	"	5 mg	2	2	3	1
..	..	..	"	2×5 mg	18 and 1	1	2	1
..	..	..	"	12.5 mg	2	2	0	8

* P.S. = Pituitrin-S, Parke Davis & Co., 1 ml containing 20 oxytocic units and 20 pressor units. ACTH = Adrenocorticotropic hormone, batch H3706, 12.5 mg containing 0.5 oxytocic units and 0.375 pressor units.

† I.D. inj. = Intradermal injection. ‡ I.V. inj. = Intravenous injection.

ously described (*2*). The rabbits were prepared by a single intradermal injection of 0.25 ml of the undiluted filtrate, and 24 hr later injected intravenously with the same filtrate diluted 1: 17.5, in a dose of 1 ml per kilo of body weight. Although the batch of the filtrate employed was not titrated to the end point, it may be safely assumed in accordance with previous experience with numerous similar preparations that the doses employed represented at least 50 minimal phenomenon-eliciting units. Readings of the reaction were made 4 and 24 hr following the intravenous injection. "Strongly positive" reactions were areas of severe confluent hemorrhagic necrosis varying in size only (i.e., 2×3 cm to 8×5 cm). "Doubtful" reactions were areas showing mild confluent or petechial hemorrhage. The substances under investigation were injected intramuscularly at various intervals of time preceding the preparatory and provocative injections of the bacterial filtrate, as indicated in Table 1.

As may be seen from the results summarized in the table, adrenocorticotropic hormone did not influence the phenomenon when injected prior to the preparatory injection. However, the administration of a sufficient dose of the hormone (12.5 mg per animal) preceding the provocative injection completely suppressed the phenomenon in 8 out of 10 animals tested. Smaller doses of adrenocorticotropic hormone similarly injected produced only irregular inhibition. The results may be considered highly significant when contrasted with the high incidence of reactions obtained in the control groups. It is also obvious that the suppression of the phenomenon cannot be attributed to the presence of oxytocic and pressor substances in the adrenocorticotropic hormone, since surgical pituitrin containing larger amounts of these substances than those present in 12.5 mg of adrenocorticotropic hormone failed to produce this effect. The limited amount of the hormone available did not permit investigations on the optimal time-dosage relationship.

It may be concluded from these experiments that the adrenocorticotropic hormone fails to prevent the elicitation of the state of reactivity following the preparatory injection. It is capable, however, of preventing hemorrhagic necrosis in reactive skin sites following the provocative injection. The interest of the studies reported is twofold: 1) they may afford a new experimental approach for the elucidation of the beneficial therapeutic effect of the adrenocorticotropic hormone in various diseases affecting the collagenous and vascular systems; and 2) they may provide a useful method for bioassaying of the hormone.

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A Simple Tissue Homogenizer

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For the preparation of tissue homogenates we have found that a simple plunger made from pure gum tubing and a glass rod (Fig. 1), and operated by hand in a test tube, is as effective as more elaborate motor-driven homogenizers. A homogenate of rat liver or kidney almost completely free of intact cells and containing nuclei and mitochondria can be prepared by this means in about

3 minutes. The device is described here for use especially in those instances in which the purchase or construction of the common motor-driven homogenizer with a special blown glass or stainless steel pestle (*2*) is not practicable.

An assembly suitable for grinding 8–10 g of tissue can be made in the following manner. A section of soft pure gum tubing 22 mm in diam, 45 mm long, with a 9-mm bore, is cemented to a glass rod 9 mm × 300 mm, with a rubber adhesive used for joining rubber to hard surfaces.

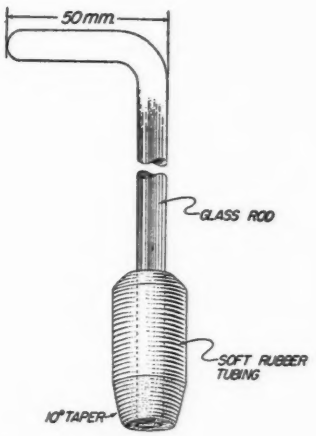

FIG. 1.

The plunger is used with a thick-walled test tube 22 mm × 160 mm. To aid in trapping pieces of tissue between the plunger and the wall of the test tube, the plunger is tapered or rounded on a grinding wheel or sanding belt (Fig. 1), and the inner wall of the test tube is roughened with moderately fine emery paper. Thorough homongenization is obtained even without the taper and roughening of the glass, although occasional small bits of tissue may not be broken up. A comfortably snug fit between plunger and test tube is easily obtained by selecting the appropriate diameter of rod and by taking advantage of the normal variation in test tube diameter. Homogenizers of various sizes have been made successfully with different types of pure gum tubing.

Homogenization is carried out by placing tissue pieces of about 3 mm in their longest dimension in the test tube, adding the dilution medium, and grinding with a motion as in washing a test tube with a brush. For sterile preparations the homogenizer can be autoclaved and the glass rod manipulated through a sterile cotton plug (*1*).

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Certain Physical Properties of Some Substituted Diphenyl Sulfones and Sulfoxides

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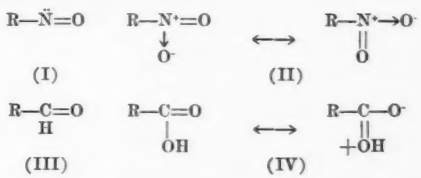
It is a well-known fact that sulfones, as a class, are extremely stable substances. The oxygen is so firmly attached that its removal is usually impossible without further disruption of the molecule. On the other hand, the sulfoxides, which are in the next lower scale of oxidation, are quite reactive toward a variety of chemical reagents. They are easily oxidized to sulfones and reduced to sulfides.

These differences in chemical behavior between the two types of sulfur compounds in different states of oxidation seem to parallel, in a general way, the differences which exist between certain nitrogen compounds differing in oxidation state. The nitroso compounds (I) (lower state of oxidation) are much more reactive chemically than the nitro compounds (II). The nitroso compounds undergo addition reactions to the nitrogen-oxygen multiple bond, are easily oxidized and reduced, and display a willingness to undergo chemical changes not shown by the nitro compounds. The parallelism also exists among certain carbon compounds. Aldehydes (III), for example, possess much of the reactivity of nitroso compounds (I) and again differ from the acids (IV) by a carbonyl activity that is repressed in the acids.

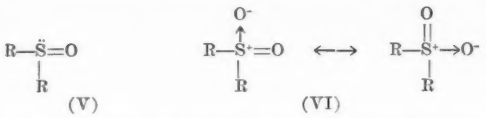


This reactivity is again noticed in the relatively facile addition to the aldehyde carbonyl group, its easy oxidation and reduction, etc.

The present widely accepted explanation for the relative stability of nitro compounds and carboxylic acids (or carboxyl anions) is that the structures are resonating and actually do not possess true multiple and coordinate covalent linkages but rather contain linkages which are the result of hybridization of the two. The lower oxidized forms, on the other hand, are considered to demonstrate the presence of true multiple linkages.

If one extends this line of reasoning to the sulfoxides and sulfones, it is apparent that the sulfoxides should owe their chemical reactivity to the presence of a sulfur-oxygen double bond (V). Here neither sulfur nor oxygen is charged as in the coordinate covalent representation

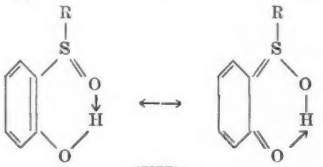
[1] We are glad to acknowledge our indebtedness to Miss Elizabeth Peterson of the Department of Chemistry, University of Illinois, who determined the infrared spectra.



(V) (VI)

and a single pair of electrons remains unshared on the sulfur atom. During oxidation to the sulfone, this pair presumably forms a coordinate covalent with an oxygen atom. The establishment of the coordinate bond creates a unit positive charge on the sulfur and a unit negative charge on the oxygen. In order that these charges may approach a minimum, a neutralization occurs and resonance results. The final structure (VI) then closely approaches that of the nitro group and the carboxylic anion. The chief advantage of the resonating decet shell representation for sulfone sulfur over and above the octet and dodecet formulas is that it draws a sharp distinction between sulfoxides and sulfones, and secondly that it permits a simple and rational explanation for the stability of sulfones.

It was believed that if the sulfur-oxygen bond had appreciable double-bond character the effect on neighboring groups should be of a recognizable type. For example, in *o*-hydroxydiphenyl sulfoxide (IX, Table 2), the interaction of the hydroxyl and sulfoxide groups might conceivably lead to the establishment of a new resonating system (VII).



(VII)

The formation of such a resonating chelate structure would be apparent by a marked shift in the characteristic absorption band of the hydroxyl group in the infrared region, and by at least a partial fixation of the double-bond system of the benzene ring.[2]

If sulfone oxygen atoms are of the type indicated in (VI), one would expect the chelation in *o*-hydroxydiphenyl sulfone (VIII$_1$, Table 2) to be weaker than in the corresponding sulfoxide (IX, Table 2) with the result that the infrared spectrum of the sulfone should show an OH absorption peak less displaced toward longer wavelengths from the position (approx. 3615–3625 cm^{-1}) characteristic of nonbonded OH groups in simple phenols. As expected, the *o*-hydroxydiphenyl sulfone (VIII$_2$, Table 2), when examined as a solid suspension in Nujol, showed a sharp OH peak whose center could be accurately located at 3357 cm^{-1}.[3] However, the OH band of the sulfoxide (IX, Table 2), under the same conditions, was so far displaced toward longer wavelengths as to merge almost completely with the C-H absorption, making its exact location impossible to determine. Because, as will be shown, both these compounds are essentially monomeric, there can be no doubt that the intramolecular interaction is vastly greater in the sulfoxide than in the sulfone.

Since the magnitude of the hydroxyl shift in the sulfoxide approximates that found in corresponding carbonyl compounds, it provides a powerful argument for the existence of a double bond between sulfur and oxygen in that structure. The only alternative, which is a coordinated oxygen, may be dismissed as being entirely inadequate to explain the observed result.

TABLE 1

MOLECULAR WEIGHTS IN NAPHTHALENE

Compound	Molality	Observed mol. wt	α*	Formula weight
VIII$_1$				234.3
	.0480	235.7	1.006	
	.0960	235.4	1.005	
	.1437	237.8	1.015	
	.2177	241.5	1.031	
	.2889	244.6	1.044	
	.3595	247.5	1.057	
	.4617	251.7	1.074	
	.5356	254.7	1.087	
VIII$_2$				234.3
	.04725	280.8	1.199	
	.09286	317.4	1.355	
	.1643	368.4	1.572	
	.2404	417.0	1.784	
	.3357	477.7	2.039	
	.4062	517.1	2.207	
	.4998	568.2	2.425	
	.5939	615.5	2.627	
IX				218.3
	.05179	213	0.974	
	.09887	219	1.01	
	.1438	223	1.02	
	.1892	224.6	1.029	

* α = Association factor = $\frac{\text{observed mol. wt}}{\text{formula wt}}$.

The displacement observed with the hydroxy sulfone likewise appears to be too large to be explainable by means of coordinated oxygens. This effectively disposes of the octet shell for sulfur in sulfones. The displacement, however, is not great enough to allow one to write two doubly bonded oxygens, since this type of structure should have the same, or nearly the same, effect on the hydroxyl shift as was observed in the sulfoxide. The dodecet formulation appears therefore to be quite inadequate in this regard also. There remains only the decet, and we have already stated cogent reasons for believing this to be of a resonating type.[4]

In order to be able to interpret the spectra more clearly and to determine more exactly the quantitative aspects of chelation versus association in hydroxy sulfones, we have determined the molecular weights of the isomers

[2] We are now examining the rearrangement of 2-hydroxy-4-allyloxydiphenyl sulfone and sulfoxide and the diazonium coupling of 2,4-dihydroxydiphenyl sulfone and sulfoxide to determine whether bond fixation exists.

[3] Hilbert, G. E., *et al.* (3) examined the IR spectrum of 2-naphthol-1-sulfone in dilute solution in carbon tetrachloride and found no hydroxyl absorption in the region of the first overtone. This was taken to indicate that both hydroxyl groups are bonded to the sulfone group.

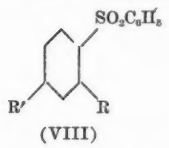
[4] Toussaint (4) has likewise proposed the resonating decet shell for sulfone sulfur as an explanation of the observed x-ray spectra of derivatives of diphenyl sulfone.

$VIII_1$ and $VIII_2$, and of compound IX cryoscopically in naphthalene.[5] These data, shown in Table 1, illustrate the striking difference between the isomers, and the very considerable extent of group interaction. It is hardly to be doubted that molecular weight determinations on other similar pairs would afford comparable results. The monomeric nature of *o*-hydroxydiphenyl sulfoxide is also demonstrated.

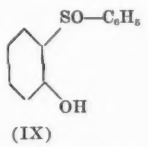
As a means of detecting chelation or association in the remaining compounds listed in Table 2 we have used the convenient and reliable method of wet melting point depression.[6] These materials were synthesized partly as intermediates and also to provide the basis for the further study of related compounds.

TABLE 2

Compound	Melting point in °C		Depression in °C
	Dry	Wet	
VIII			
1. R=OH, R′=H	96–98	83.5	12.5
2. R=H, R′=OH	135–136.2	84	51
3. R=OH, R′=OCH_3	114–115.4	103.5	10.5
4. R=OCH_3, R′=OH	167–170	116	51
5. R=H, R′=OCH_3	90–90.6	80	10
6. R=OCH_3, R′=H	141–142	125	16
7. R=R′=OCH_3	119–119.5	103	16
8. R=NH_2, R′=H	118–120.5	107	11
9. R=H, R′=NH_2	166–172	133.5	32.5
10. R=NH_2, R′=OCH_3	126–127.5	113	13
11. R=OCH_3, R′=NH_2	130–131	102	28
IX	162–164	159	3



(VIII)



(IX)

It is apparent from the data in Table 2 that both the hydroxyl group and the amino group are capable of significant interaction with the sulfone group. When the interacting groups are *para*, the result of interaction is association of molecules, whereas when they are *ortho*, the result is the establishment of a chelated structure which would be expected to be essentially monomeric. Hence, when the *para* isomer is melted in the presence of moisture, the polar water molecules become bonded with the sulfone group, displacing the phenolic hydroxyls (or amino groups) and thereby breaking up the associated complex. In the case of the *ortho* isomer, it appears that water molecules are bound but, due to the absence of polymeric units, the effect is relatively minor. This interpretation seems to be indicated because of the behavior of the methoxy sulfones, which also suffer melting point depressions when wet. Since *p*-hydroxydiphenyl sulfoxide was not available for study, no comparison with the *ortho* isomer can be made, but the very small depression of this isomer indicates strong chelation.

A more complete account of the experimental details of this work will be published elsewhere.

[5] Details of the apparatus and method employed will be discussed fully in a forthcoming paper by one of us (I. M. H.).

[6] The use of the comparison of wet and dry melting points to distinguish between chelation and association has been well-established by the work of Baker (*1*) and Hunter (*2*).

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Abundance of N^{15} in the Nitrogen Occluded in Radioactive Minerals

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The presence of elementary nitrogen in the gases occluded by uranium minerals was established by Hillebrand's (*3*) analyses of uraninites and pitchblendes from diverse localities. This discovery was overshadowed by the detection of helium in these minerals by Ramsay (*5*). Subsequent investigation of pitchblende from Katanga, Belgian Congo, and of a uraninite crystal from Keystone, South Dakota, by Davis and Kennedy (*1*) revealed the presence of nitrogen as well as helium. Analyses of the occluded gases showed the presence of 0.159% helium by weight and 0.075% nitrogen in the pitchblende, and about 0.03% of each in the uraninite.

In an investigation of the occluded gases in radioactive minerals by means of the mass spectrometer, we have detected nitrogen and helium in the fraction isolated by ignition of the samples and remaining uncondensed in a liquid air trap. The isotopic ratio of N^{15} to N^{14} in these samples was invariably higher than in samples of atmospheric air or in nitrogen isolated from nitrogenous compounds.

The gases were isolated by heating the freshly ground minerals to a bright red heat for several hours in a quartz tube sealed through a graded seal to the gas inlet system of the mass spectrometer. To eliminate interference with the nitrogen peaks at masses 28 and 29 by the carbon monoxide peaks at the same masses, the liberated gases were passed through a U-tube containing I_2O_5 maintained at 145° C to oxidize any carbon monoxide that might be present. Water, carbon dioxide, and oxides of sulfur, liberated by the thermal decomposition of the mineral and its associated gangue, were separated by means of two liquid air traps. The gases not condensed in the liquid air traps were analyzed from mass 12 through mass 44 in all of the samples and from mass 4 to mass 90 in many of them. The mass spectra showed a high percentage of helium, a trace of methane, and from 5% to 10% nitrogen by volume. No attempt was

[1] We wish to express our appreciation to W. F. Foshag and E. P. Henderson of the U. S. National Museum for providing us with certain of the specimens used in this work.

TABLE 1

N^{15} CONTENT IN GASES OCCLUDED BY URANIUM MINERALS

Specimen	Locality	Composition		Geological age in years	N^{15} abundance atom%
		U_3O_8%	ThO_2%		
Pitchblende	Woods' Mine,* Central City, Colorado	76.7	0.018	57×10^6†	0.532 ± 0.005
Uraninite crystal	Spruce Pine,§ North Carolina	~91	~3	251×10^6‡	0.546 ± 0.009
Samarskite	Spruce Pine,‖ North Carolina	11.3	0.8	$\sim 250 \times 10^6$	0.549 ± 0.015
Pitchblende	Katanga, Belgian Congo	78.8‖	.....	625×10^6¶	0.575 ± 0.003
Pitchblende	Shinkolobwe, Katanga, Belgian Congo	~89	.....	625×10^6**	0.574 ± 0.011
Uraninite	Wilberforce, Canada	72.5	10.6	1050×10^6¶	0.614 ± 0.012
Pitchblende	Great Bear Lake, Canada	63.6††	.....	1251×10^6¶	0.586 ± 0.005

* U. S. Nat. Mus. 83629, analysis by H. Yagoda.
† Nier, A. O., Thompson, R. W., and Murphy, B. F. *Phys. Rev.*, 1941, **60**, 112.
‡ Holmes, A. *Radioactivity and Geological Time*, Bull. No. 80, Nat. Res. Council, Wash., D. C., 1931, p. 342.
§ Approximate analyses cited by Holmes‡ for specimens from the same locality.
‖ Analysis by H. Yagoda.
¶ Nier, A. O. *Phys. Rev.*, 1939, **55**, 159.
** U. S. Nat. Mus. 8403, a high grade specimen with U_3O_8 content of approximately 89% and probably of the same age as the other Katanga mineral.
†† A specimen from vein 2; analysis by H. Yagoda.

made to obtain accurate quantitative measurements on these gases. A small peak at mass 30 was observed in most of the minerals analyzed, and it may be attributed to $N^{14}O^{16}$ formation. There was no evidence of argon in any of the samples within the sensitivity of the instrument (approximately 0.03% A^{40}).

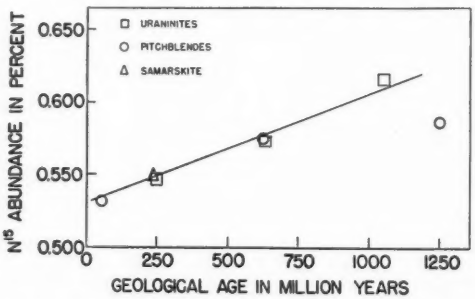

FIG. 1. N^{15} abundance of uranium minerals plotted against their probable geological age.

As shown in Table 1 the percent abundance of N^{15} in the nitrogen from old uranium minerals is abnormally high, measuring from 0.532% to 0.586%, as compared with the normal abundance of 0.376% (*6*). Determinations with our mass spectrometer[a] gave a value of 0.371 ± 0.002 for atmospheric nitrogen and 0.374 ± 0.001 atom % N^{15} in nitrogen isolated by the thermal decomposition of ammonium dichromate. In an effort to obtain a measurement on occluded nitrogen from a nonradioactive, but old, source, a sample of scheelite was ignited, but the quantity of gas liberated was too small for analysis. A sample of monazite sand from India, containing about 10% thorium and only traces of uranium, furnished a small quantity of nitrogen with an abundance of 0.600 ± 0.006 atom % N^{15}.

The association of nitrogen with helium in radioactive minerals has been attributed either to mechanical occlusion or internal accumulation by the hypothetical decay of U^{238} into nitrogen nuclei (*2*). Lind (*4*) has proposed that the nitrogen gas is formed in the mineral by the radiochemical decomposition of some nitrogen compound, possibly uranium nitride, by the action of alpha particles. Our observation of an abnormal N^{15} abundance, roughly proportional to the geological age of the specimen (Fig. 1), suggests that the nitrogen may have been present as a constituent of the mineral at the time of its formation and that the N^{15} content was augmented by the more rapid diffusion of the N^{14} isotope. However, with our present knowledge, none of these hypotheses adequately explains this phenomenon.

[a] Westinghouse Type LV mass Spectrometer with a Nier type capillary leak.

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Growth of *Chlorella vulgaris* in the Dark

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During metabolic studies on *Chlorella vulgaris*[2] now in progress in this laboratory, it was found desirable to make use of very small inocula for starting liquid cultures. The culture medium consisted of a complete Hoagland solution to which 1% glucose was added. It was observed early in this work that such cultures when kept in a dark chamber did not show any visible signs of growth. However, when they were brought out into ordinary daylight, even after as long as 70 days in the dark, they grew in the same manner as do freshly inoculated cultures. In view of the numerous statements in the literature that *Chlorella* species and other algae grow and produce chlorophyll in the dark (*1, 4*), it appeared desirable to investigate this phenomenon further.

TABLE 1

EFFECT OF PERIODS OF DARKNESS AND LIGHT ON THE GROWTH OF *Chlorella vulgaris*

Total weeks of growth	Weeks in dark	Followed by weeks in light	Cells/mm³
1	1	0	±*
1	0	1	100
3	1	2	400
3	0	3	4,000
6	3	3	1,200
6	0	6	39,000
10	10	0	±*

* Cultures water-clear; too few cells to count.

The initial trials were simply repetitions of the first experiments to make sure that what we had observed was not an artifact. A number of 250-ml culture flasks arranged for continuous aeration were each filled with 150 ml of complete Hoagland solution containing glucose and inoculated with small inocula of *Chlorella vulgaris* (2,000–10,000 cells per flask). A few of these were left in the ordinary daylight; the rest were placed in a dark chamber. Periodic obesrvations indicated that while the flasks in the light were detectably green after about 5–6 days, those in the dark did not show any signs of growth for as long as they remained in the dark, even up to 10 weeks.

At intervals, two flasks from the dark chamber were removed and placed in the light, where their growth was observed. At the same time periodic hemocytometer cell counts made on the cultures remaining in the dark revealed that these water-clear cultures, even after 10 weeks, contained too few cells to make a count possible. The results of the experiment are summarized in Table 1.

Other cultures were exposed for 10 days to the light, permitting a visibly green culture to develop, and were then placed in the dark. At 6 weeks from the time of inoculation they showed a count of 2,400 cells/mm³; the count was roughly the same at 10 weeks. Then when the cultures were exposed to light, they again started growing, although after a relatively long lag period.

It should be noted here that cells that have been in the dark for a long time lose practically all their chlorophyll, become much larger than their normal size, and appear to be granular. Such cells seem to have the capacity to recover if exposed to light. However, a few of the dark-grown cultures that were retained in the dark for 12 weeks became completely devoid of chlorophyll and did not recover the ability to resynthesize chlorophyll or show any signs of growth after exposure to light.

A preliminary attempt was made to find whether certain simple substances added to the medium would affect growth in the dark. To cultures which were grown in regular culture flasks as described, and which were started with small inocula, there was added, besides glucose, one of the following substances: yeast extract, indole acetic acid, glucoseamine, asparagine, vitamin B_1, and ascorbic acid. In all these cases the results with respect to growth in the dark were the same as in the Hoagland solution plus glucose, i.e., there was no observable growth. The controls in the light grew normally.

The results of these experiments indicate that this particular strain of *Chlorella vulgaris* seems to require for growth a factor (other than carbohydrate) which is either photochemically synthesized or activated and which is depleted in darkness. The possibility of a growth inhibitor adversely affected by light is also being considered in experiments now in progress.

The apparent discrepancy between the observations here reported and those reported in the literature may be explained by one of two suggested possibilities. First, we may have a strain of *Chlorella vulgaris* that has lost the capacity to grow or produce chlorophyll in the dark. This possibility is now being tested by growing a number of other strains under similar conditions. The other possibility is that in order to observe this phenomenon as strikingly as it is reported here, it is essential to use extremely small inocula and to observe the cultures for long periods of time. It is not evident that such conditions prevailed in experiments on growth of algae in darkness which have been described in the literature.

[1] Fellow of the National Cancer Institute.

[2] The original cultures of these algae were obtained from Dr. Robert Emerson in 1931 and have been cultured in this laboratory since then.

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Studies on Pain[1]

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A series of investigations is being carried on at this hospital on physiological and clinical aspects of spontaneous and induced pain. This report deals with vasomotor response to noxious stimuli. Our observations have shown that though peripheral vasoconstriction is evolved by noxious stimuli it is not synchronous with pain perception and hence cannot be directly interpreted as an indication of the presence or degree of pain. Nevertheless, it is felt that studies of the vasomotor response under carefully controlled conditions are useful in the evaluation of analgesic drugs which may supplement presently available testing methods (*5*).

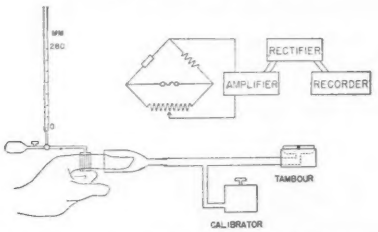

FIG. 1. Schematic drawing of the plethysmographic equipment.

A soundproofed experimental room measuring 8 ft × 8 ft × 10 ft was constructed. The temperature is controllable to within ± 2° F and was maintained at 78° F. The humidity is controllable within ± 5%–10% and was maintained between 30%–40% during each experimental period. The studies were conducted on subjects lying comfortably in bed.

Blood flow of a finger tip is measured plethysmographically. A plastic finger cup, the edges sealed with printer's roller compound, is connected with thick rubber tubing to a strain gage which transforms mechanical deformations of a rubber membrane to electrical energy. The gage has been made one arm of a Wheatstone bridge and the subsequent voltage imbalance is amplified and recorded on a GE Photoelectric recorder Model No. 8CE3FL21A (*4*). The linearity of amplification, natural frequency response of the rubber membrane, and relationship of rate of vibration to linear deflection of the stylus were investigated and found to be adequate for this study. A device consisting of a bellows which displaces a known volume of air (.025 cc) into the closed system was used for calibration. A cuff is applied proximally to the finger cup, and its inflation permits instantaneous venous occlusion (Fig. 1).

The noxious stimulus is a brief condenser discharge of intensities ranging from 0 to 92 volts in 23 steps. The stimulating electrodes are two hypodermic needles (gage 26) inserted intracutaneously in the dorsum of the feet. It has been found that an adaptation stimulus (*3*) consisting of an auditory impulse spaced at 8-sec intervals with a duration of ½ sec contributes to the stabilization of the blood flow. The effect of the noxious stimulus is thereby more sharply defined.

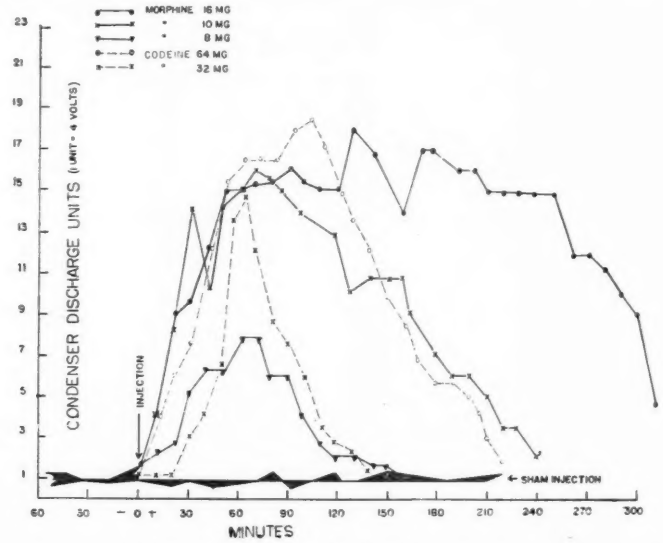
MORPHINE 16 MG
" 10 MG
" 8 MG
CODEINE 64 MG
" 32 MG
CONDENSER DISCHARGE UNITS (1 UNIT = 4 VOLTS)
INJECTION
SHAM INJECTION
MINUTES
60 50 0 30 60 90 120 150 180 210 240 270 300

FIG. 2. Elevation of vasomotor threshold responses following administration of analgesic drugs. No significant change is seen after sham injection.

[1] Supported by grant from Roche Anniversary Foundation.

TABLE 1

VASOMOTOR-THRESHOLD RESPONSE TO ANALGESIC DRUGS

Analgesic injected subcutaneously	Dose mg	Vasomotor-threshold area (sq in.)	Effect expressed in time (min)
Morphine	·16	38.5	300
"	"	24.5	310
"	"	22.7	310
"	"	30.3	340
"	10	16.2	270
"	8	2.0	120
"	"	5.0	140
Codeine	64	17.3	220
"	"	16.8	200
"	32	5.5	180
"	"	4.3	140
Demerol	100	29.8	260
"	"	35.1	330
"	50	18.2	270
"	"	19.5	270
NU 1196*	30	14.5	230
"	15	4.0	150
"	"	6.4	130

* This is an experimental drug from Hoffmann-La Roche, Inc., containing DL-a-1,3-dimethyl-4-phenyl-4-propionoxypiperidine hydrochloride.

Threshold. The subject under study—after stabilization in the room, and adaptation to the auditory stimuli—is subjected to the noxious stimulus at 10-min intervals. The minimum intensity of a stimulus which evokes on two consecutive trials a vasoconstrictor response—as evidenced by diminution of stroke volume and depression of the base line—is considered to be the threshold of the subject. It has been found that, over a period of several hours, this threshold fluctuates within a narrow margin only and remains uninfluenced by placebos. Analgesic drugs elevate this value consistently. In Fig. 2 are shown the mean values of threshold changes, following the administration of morphine at three dose levels and codeine at two dose levels in one patient. In Table 1 are shown the threshold changes in a subject following the administration of analgesics—three standard and one experimental. The charted areas representing the elevation of the threshold above the pretreatment levels are measured with a planimeter and expressed in square inches; the duration of this elevation is expressed in minutes.

The varying degrees of potency of different analgesic drugs and the effect of one drug in varying doses are shown in Fig. 2 and Table 1.

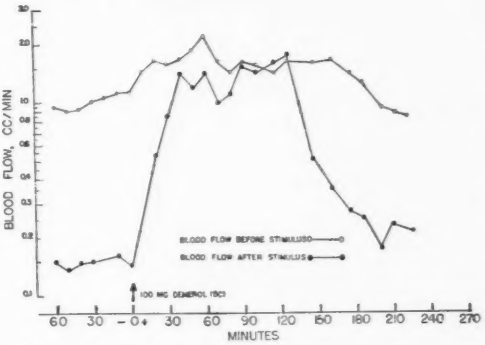
BLOOD FLOW, CC/MIN
BLOOD FLOW BEFORE STIMULUS
BLOOD FLOW AFTER STIMULUS
100 MG DEMEROL (SC)
60 30 0 30 60 90 120 150 180 210 240 270
MINUTES

FIG. 3. Blood flow in cc/min before (upper graph) and after (lower graph) painful stimuli. At 0 min an analgesic was injected and the vasoconstriction due to painful stimuli (lower graph) decreased during the phase of analgesia.

The elevation of threshold induced by the analgesic drugs used has been found to be quite uniform and reproducible in a single subject. The absolute response in different subjects may vary. In testing several subjects one can correct this variation by using a standard drug of reference for each subject under investigation.

Blood Flow. Blood flows were determined by the conventional venous occlusion methods and expressed as cc/min/finger volume (*1, 2*). In Fig. 3 the blood flow of one subject, before and after noxious stimulation, is shown. As can be seen from this figure, considerable reduction in blood flow resulted from application of constant stimulus above threshold. Administration of an analgesic drug resulted in increase in the absolute blood flow and decrease of vasoconstriction after stimulation. The values before and after noxious stimulation approximated each other 80 min after the administration of the drug. This approximation represents the maximum effectiveness of the particular analgesic drug under study. With the gradual loss of analgesia, the vasoconstriction after stimulation again becomes manifest. Quantitative studies of the effects of various analgesic drugs on the blood flow are being made.

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Comments and Communications

Geologic Age from Metamict Minerals

Advances in the determination of the age of geological materials depend on the improvement of existing techniques and the development of new methods. The idea discussed below may be the basis of another absolute age method.

Studies of the isodesmic multiple oxides (i.e., those multiple oxides in which all cation-anion bonds have similar strength) of the type $A_mB_nO_{2(m+n)}$, where A = U, Th, rare earths, Ca, Na, etc. and B = Nb, Ta, Ti, etc., have shown partial or complete absence of internal crystal structure while displaying macroscopic crystal faces. They may thus be said to be in the metamict state. (A metamict mineral is defined as a noncrystalline pseudomorph of the original mineral.) It has also been shown that in other cases the internal structure is preserved. Muegge (Centralblatt f. Mineralogie 1922, pp. 721–739 and pp. 753–765) has shown that heating metamict gadolinite—i.e., gadolinite which yields no x-ray pattern—converts the isotropic mass into an anisotropic material with a crystal structure identical with that of nonmetamict gadolinite. Similar behavior has been noted for other minerals of the group described above (Dana's System of Mineralogy, 7th Ed. Vol. I., John Wiley and Sons, 1944) and especially for the mineral microlite. Important minerals of the group which may occur in the metamict state also include pyrochlore, fergusonite, formanite, euxenite, polycrase, eschynite, priorite, samarskite, and betafite. It appears that zircon may also be metamict. If age determination by this method is practical it is of considerable importance, since zircon can be separated from most granites.

A recent survey of the isodesmic multiple oxide group by differential thermal analysis at Columbia University (unpublished) has shown that the return to the crystalline state proceeds at a definite temperature with a considerable evolution of heat. It seems plausible to assume with previous authors that these minerals were originally crystalline, and that destruction of the crystal lattice has taken place since their formation through alpha bombardment from the uranium and thorium in the lattice.

If this is the true mechanism, it follows that the amount of destruction of the lattice is affected by (1) the inherent stability of the given mineral structure, (2) the total alpha activity of the mineral, and (3) the time that has elapsed since the formation of the mineral. If the first two variables can be specified and if the degree of destruction of the lattice can be quantitatively measured, then the age is uniquely determined.

The amount of disorder created by alpha bombardment of the lattice can be measured by means of thermal analysis, since the area under the exothermic peak on the thermal record will be proportional to the amount of heat generated in the specimen upon returning to the crystalline state. For a particular mineral type the strength of the bonds, and hence the stability, will be essentially constant for all specimens. Some variation in the substituted cations should produce only a second order effect. The total alpha activity could be determined either by direct alpha counting or by uranium and thorium analyses. A knowledge of the damage done to the lattice and the alpha activity of the mineral should therefore permit estimation of the age of the particular specimen. It should be pointed out, however, that in a given specimen the rate of destruction of the lattice must decrease with time. Thus, for materials which are completely metamict, it would be possible to determine only a minimum age. In many geological applications, however, even information of this nature would be very useful.

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Correction

In our article "Mesons Produced by the Cyclotron" (Gardner, E. *et al.* *Science*, 1950, **111**, 191) there is a typographical error on page 196 in the table near the top of the page. The first entry in the right-hand column reads 28.8 and should read 26.8.

EUGENE GARDNER

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A Modified Schiff's Solution

In connection with the article by J. Alexander, K. S. McCarty, and E. Alexander-Jackson (*Science*, 1950, **111**, 13), I should like to call attention to my paper "A Modified Schiff's Solution" (*J. Amer. chem. Soc.*, 1922, **44**, 1834).

There are some additional facts in this paper which might be of interest to the readers of *Science*.

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Department of Chemistry
University of Arkansas, Fayetteville

Dramamine

The use of Dramamine in the prevention and therapy of motion sickness (Gay, Leslie N. and Carliner, Paul E. *Science*, 1949, **109**, 359; Strickland, Benjamin A. and Hahn, George L. *Science*, 1949, **109**, 359) and in the treatment of the nausea and vomiting of pregnancy (Carliner, Paul E., Radman, H. Melvin, and Gay, Leslie N. *Science*, 1949, **110**, 215) has attracted widespread attention. Although some of the procedures employed in these studies have been criticized (Tyler, David B. *Science*, 1949, **110**, 170), the results provide at least preliminary evidence of the efficacy of this treatment. However, it has come to the writer's attention that these papers have

left many readers with the impression that Dramamine is a basically new agent with unique pharmacological and therapeutic properties. All the articles cited failed to mention the fact that Dramamine is simply an organic salt of a compound, the hydrochloride of which has been recognized by the Council on Pharmacy and Chemistry for several years under the official name of *diphenhydramine* and which has been widely marketed and prescribed under the trade name *Benadryl*.

An additional note on Dramamine (Cusic, John W. *Science*, 1949, 109, 574) has suggested that formation of the 8-chlorotheophylline salt might reduce the sedative effect that is not uncommonly observed with diphenhydramine. However, absolutely no pharmacological or clinical evidence was presented to substantiate this contention. Available pharmacological data point to the conclusion that 8-chlorotheophylline, in the amount administered (45 mg orally), would have little or no detectable pharmacological action. This dosage of theophylline is essentially inactive in man and the 8-halogen substitution appears to reduce all pharmacological properties of the parent compound (Green, D. M., *et al. Fed. Proc.*, 1949, 8, 296). From these considerations, it appears highly improbable that the therapeutic properties of Dramamine and diphenhydramine differ significantly except inasfar as the heavy anion in Dramamine may reduce the percentage of active substance.

Science is a publication designed primarily for the broad dissemination of scientific information and not as an organ for the purpose of launching proprietary pharmaceutical preparations. It may be hoped that in the future the constituents of proprietary salts or mixtures may be more clearly identified for those readers who fail to stop and translate chemical descriptions into terminology commonly applied to the active principles involved.

MARK NICKERSON

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Book Reviews

Atomic Medicine. Charles F. Behrens, Ed. New York: Thomas Nelson, 1949. 416 pp. $7.50.

This timely volume dealing with medical aspects of nuclear science represents an attempt by a group in the Navy to provide a source of basic information primarily regarding radiation derived from radioactive isotopes. The book is written in simple language and can readily be understood by anyone with scientific training. The terminology peculiar to radiologists has been carefully avoided except when it adds clarity to the discussion. There are chapters dealing with the pathology of total body irradiation, the physical background for radioactivity, ionizing radiations and their biological effects, methods of detection and measurement of radiation, tracer methods in the biological application of radioisotopes, the atomic bomb in action in Japan and the planning necessary to deal with an atomic bomb explosion in the future.

In any field that suddenly becomes of great and widespread interest, a newcomer needs information that is hard to find in scattered papers in the literature. By meeting some of his needs it is inevitable that those demands not met should stand out in glaring relief. Although Cronkite, Geschickter, and Copeland in particular have provided numerous references to the literature in the fields covered by the chapters they contributed, it is to be regretted that more specific references were not provided for readers who want to go to original sources. The greatest omission was a thorough discussion of dosimetry of radioactive isotopes. An understanding of the principles and methods of calculation of radiation delivered by the administered isotopes is a prerequisite to their intelligent use by the physician.

More ruthless editing would have eliminated duplications in the historical background supplied by the various contributors. This would have removed an unnecessary sense of repetitiveness that the reader now gets from the book. The styles of the various authors, although showing individual differences, are sufficiently similar to give a homogeneity to the book not always found in joint efforts.

The chapter on the design and operation of laboratories employing radioactive isotopes in medical research will be most helpful to those not yet acquainted with many of the specific requirements of such installations. The hazards are pointed out without alarm and means for combating them described.

The book is pleasing in format, the figures and illustrations are clear, and typographical errors are at the absolute minimum.

LEE E. FARR

Brookhaven National Laboratory

Medical Etymology: The History and Derivation of Medical Terms for Students of Medicine, Dentistry, and Nursing. O. H. Perry Pepper. Philadelphia: W. B. Saunders. 1949. 263 pp. $5.00.

This little volume of less than 4,000 words makes no pretense of being a dictionary; it is a history of medical terms for students of medicine, dentistry, and nursing. The author, an eminent internist, has observed the change in premedical education from emphasis on Greek and Latin in days gone by to the current deletion of the classic and more rigid requirements in the biological and physical sciences. The impact on the present-day student entering medicine, dentistry, or nursing of a new and bewildering terminology creates confusion and unquestionably contributes to the high attrition in the freshman year. Not only must he master the discipline but he must learn simultaneously a new language—a task for

which he is unprepared. In former days training in Greek and Latin gave him an acquaintanceship with word-building from prefixes and suffixes, the compounding of roots, which helped greatly in understanding new words.

The medical terms with their descriptions are grouped under subjects beginning with *Anatomy*, just as the student would first encounter them in the preclinical years; then the vocabulary of the clinical subjects follows. It is perfectly obvious that the author has spent long hours in writing this book and that he derived a tremendous amount of pleasure from the task. The reader will have real difficulty in putting the book down once he has opened it to find the origin of a word. It is fascinating reading.

There are occasional errors, such as the designation of Sir James Bruce for Sir David Bruce in the creating of the genus *Brucella*. These can easily be changed in subsequent printings. The book should be in the hands of every student.

MALCOLM H. SOULE

University of Michigan

Supersensitivity of Denervated Structures: A Law of Denervation. Walter B. Cannon and Arturo Rosenblueth. New York: Macmillan, 1949, 245 pp. $5.50.

This book is a suitable companion to *Autonomic Neuroeffectors* published by the same authors in the Macmillan Series of Experimental Biology Monographs in 1937, and is the 21st and last of the joint publications of these two authors. Approximately half of the 22 chapters were completed by Prof. Cannon before his death; the remainder were written jointly or by Dr. Rosenblueth.

The phenomenon of sensitization of effectors as a result of denervation has long been known and has challenged such distinguished physiologists as Sherrington, Elliott, and Langley. Sixteen chapters of this book are devoted to detailed examples of the phenomenon of supersensitivity after denervation. Smooth muscle—for example, nictitating membrane and uterus—gives larger responses and has a lower threshold for sympathin and adrenalin some days after the sympathetic nerve supply has been cut than when normally innervated, and postganglionic denervation is more effective than decentralization. Depriving smooth muscle, like that in blood vessels, of its cholinergic nerve fibers, whether these normally excite or inhibit the muscle, accentuates the response to acetylcholine and related drugs. Similar supersensitivity is observed in melanophores of fish, in submaxillary and lacrimal glands, in vertebrate hearts, and in skeletal muscles after cutting the nerves which innervate them. Sympathetic ganglia show increased sensitivity to acetylcholine and potassium after the preganglionic fibers are cut; also to nerve impulses, as demonstrated by partial denervation. In the central nervous system there are several examples of increased responsiveness after transection of tracts impinging on certain regions; some of these instances can be interpreted as the functional opening of preexisting paths but some represent true supersensitivity of neurons. Spontaneous activity, such as muscular fibrillation and asynchronous impulses from sympathetic ganglia after denervation, is interpreted by the authors as indication of supersensitivity. In general the excitability and responsiveness increase gradually during several days after denervation.

> When in a functional chain of neurons one of the elements is severed, the ensuing total or partial denervation of some of the subsequent elements in the chain causes a supersensitivity of all the distal elements . . . and effectors if present, to the excitatory or inhibitory action of chemical agents and nerve impulses; the supersensitivity is greater for the links which immediately follow the cut neurons and decreases progressively for more distal elements.

In the final chapters several theories of sensitization are explored. These include: disuse or inactivity of the denervated structure, removal of trophic influences, decrease in cholinesterase content, and increased permeability of the cells of the denervated tissue. There is evidence for each of these theories but no one of them can account for all of the known facts of the supersensitivity after denervation. The phenomenon of sensitization has important implications with respect to persistent changes in excitability in the central nervous system—for example in reorganization of behavior after injuries. Clinical applications are mentioned but not considered in detail.

This book is a careful summary of the examples of supersensitivity after denervation, many of these examples coming from work done at the Harvard Medical School. The authors are cautious in their interpretation, and the reader is left with the feeling that here is a phenomenon ripe for investigation in terms of cellular physiology.

C. LADD PROSSER

University of Illinois

Scientific Book Register

The Sea and Its Mysteries: An Introduction to the Science of the Sea. John S. Colman. London: G. Bell and Sons; New York: British Book Centre, 1950. 285 pp. 12s. 6d. net.

Phenomena, Atoms and Molecules: An Attempt to Interpret Phenomena in Terms of Mechanisms or Atomic Molecular Interactions. Irving Langmuir. New York: Philosophical Library, 1950. 436 pp. $10.00.

An Introduction to the Study of Experimental Medicine. Claude Bernard; trans. by Henry Copley Greene. New York: Henry Schuman, 1949. 226 pp. $3.00.

Science and the Goals of Man: A Study in Semantic Orientation. Anatol Rapoport. New York: Harper & Bros., 1950. 262 pp. $3.50.

The Separation of Gases. 2nd ed. M. Ruhemann. New York: Oxford Univ. Press, 1949. 307 pp. $6.00.

Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado, September 7–20, 1948. Department of State Publ. 3382. Washington, D. C.: U. S. GPO, 1949. 782 pp.

Laboratory Fractional Distillation. Thomas P. Carney. New York: Macmillan, 1949. 259 pp. $5.75.

NEWS and Notes

National Science Foundation Bill

Statement of the Council of the National Academy of Sciences. Under date of March 9, Alfred N. Richards, as president of the National Academy of Sciences, addressed the following letter to the President of the United States:

Attached to this letter is a statement drawn up by the Council of the National Academy of Sciences. Its purpose is to set forth the principles upon which is based the attitude of the Council with respect to the National Science Foundation Bill (H.R. 4846) as passed by the House of Representatives on March First.

I have been instructed by the Council to transmit the statement first to you and then to those officers and members of the Congress who are most intimately involved in the enactment of the bill. It is designedly limited to principles so broad as to be applicable not only to science but to other intellectual pursuits. It has developed, however, from more specific considerations which it may be useful to state.

Our concern centers on the amendment introduced by Representative Smith of Virginia, which provides for FBI investigation and clearance of every person who is to be awarded a scholarship or fellowship under the terms of the bill. We are convinced that this provision, if made into law, would so distort the purpose of the original bill as to work serious damage to the development of science in the United States and to those persons upon whom that development depends.

It is fully agreed that FBI investigation and agency security clearance are necessary requirements for those who work in classified fields or have access to restricted data.

It is also agreed that federal aid under this act should be given only to persons who are of good character and are loyal to the Government of the United States.

It is maintained that the selection of persons who may justly receive federal aid under the act on the basis of character, loyalty and competence can be accomplished by the administrators of the Science Foundation without resort to FBI. Investigation by FBI of large numbers of young persons who are not suspect is not only unnecessary but may be positively detrimental to the objectives of the bill.

Knowledge of the nature of FBI investigations and reports among prospective applicants for scholarships may well be expected to develop in them habits of caution, reticence and suspicion, which are the antithesis of frank truthfulness which science demands. A deplorable trend to conformity and a deterioration in the intellectual climate could be expected to follow.

Faulty evidence or unfounded opinions which might be contained in an FBI report might lead to adverse decisions which could be irretrievably damaging to innocent persons.

There is ground for apprehension that the imposition of FBI investigation upon young persons in the Science Foundation program, for no apparently justifiable reasons of security, would lead to similar restrictions in other areas of education and science with further contravention of our traditional freedom of thought and actions.

We feel confident that further deliberations within the Congress will result in the action necessary to overcome the dangers which we envisage.

I wish to add that the principles embodied in the enclosed statement and such specific considerations as those in the preceding paragraphs formed the basis of the decision of the National Academy of Sciences to limit the participation of the National Research Council in the nonsecret part of the AEC fellowship program to advisory assistance.

Statement of the
COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES
Relating to Certain Provisions of the
NATIONAL SCIENCE FOUNDATION BILL H. R. 4846
as Passed by the House of Representatives March 1, 1950

In the great conflict which now divides the world, the American people have been forced to recognize the dangers inherent in the use of Communist ideology for subversive purposes, and the necessity of taking protective measures against this. One of the gravest threats inherent in these protective measures is that they can jeopardize the freedom of the American people and thus defeat the very purposes the measures are designed to meet.

One set of protective measures is rightly aimed at the security of information vital to the national defense. Scientific and technical information has come to play an important role in this defense. We are gravely disturbed, however, to see that security measures are being extended widely over the scientific life of the country, even in those areas remote from possible military application. This development will defeat the growth of science by inhibiting the free exchange of information so vital to it, by discouraging the bravest and most original minds, and by the pervasive threat of irreparable injury to individuals inherent in all counter-intelligence measures.

If we are concerned with these developments it is not because we ask a special privilege for scientists; it is because they cannot lose their freedom without jeopardizing the freedom of all Americans.

Basic to the American tradition is the freedom of inquiry, the right to search for truth. All progress in science depends on this, as does the freedom of our political institutions. As Jefferson wrote more than a century and a half ago: "To preserve the freedom of the human mind then and freedom of the press, every spirit should be ready to devote itself to martyrdom; for as long as we may think as we will, and speak as we think, the condition of man will proceed in improvement."

And President Coolidge said more recently in dedicating the Building of the National Academy of Sciences: "One of the most important possibilities for service of the National Academy of Sciences in the future lies in its opportunity for inspiring the people of America to insistence upon having the truth, and nothing but the truth, regarding everything that touches the life of the Nation."

This country has grown strong by encouraging individual freedom of exploration in all fields of human endeavor. To let this freedom be limited by state-imposed conformity would be to lose the birthright which is our greatest strength.

March 7, 1950

About People

David Blackwell, professor of mathematics and head of the department at Howard University, Washington, D. C., and **Robert Hofstadter,** assistant professor of physics at Princeton, will join the staff of Stanford University on September 1. Dr. Blackwell's work is in probability theory and applied mathematics, especially in social and economic problems. Dr. Hofstadter's interest is in the field of crystal counters.

V. P. Sokoloff, soil scientist with the U. S. Geological Survey since 1943, has been appointed lecturer on "The Geography of Soils" at Johns Hopkins University. Dr. Sokoloff will replace R. L. Pendleton, professor of tropical agriculture and soils at the university, who is on leave of absence.

E. B. Babcock, professor emeritus of the Division of Genetics, University of California at Berkeley, was recently elected an honorary member of the Royal Botanical Society of Belgium.

E. Gorden Young, professor of biochemistry since 1924 at Dalhousie University, Halifax, Nova Scotia, has been appointed director of the Canadian National Research Council's Maritime Regional Laboratory, now under construction on the campus of the university. The laboratory will provide a research center for scientific and industrial problems of direct interest to the Maritime provinces.

J. Stewart Hunter has been appointed assistant to the Surgeon General for information in the Public Health Service, Federal Security Agency. He succeeds **Bryant Putney,** who resigned to accept a position as assistant information director, Department of the Interior.

Verne E. Grant has been appointed biosystematist at the Rancho Santa Ana Botanic Garden, Anaheim, California. He is at present National Research Fellow at the Carnegie Institution Laboratory at Stanford University and will take over his new duties this summer.

Robert L. Pendleton, professor of tropical soils and agriculture of the Isaiah Bowman School of Geography, Johns Hopkins University, and **H. H. Love,** professor emeritus of plant breeding, Cornell University, have accepted assignments in Bangkok, Thailand, as agricultural specialists of the Office of Foreign Agricultural Relations, U. S. Department of Agriculture. They will assist the Thai government in programs of crop improvement.

Dwight E. Gray, former supervisor of technical reports of the Applied Physics Laboratory of Johns Hopkins University, has joined the Technical Information Branch of the Atomic Energy Commission as technical advisor to Alberto Thompson, chief of the branch. From September 1948 to November 1949 Dr. Gray also directed a study of physics abstracting for the American Institute of Physics.

William Webster has been appointed chairman of the Research and Development Board of the Department of Defense. Mr. Webster was formerly chairman of the Military Liaison Committee of the Atomic Energy Commission and has recently been vice president of the New England Electric System.

F. William Sunderman, formerly professor of experimental medicine and clinical pathology of the Postgraduate Medical School of the University of Texas, and director of clinical research of the M. D. Anderson Hospital for Cancer Research, Houston, will take charge of the Clinical Pathology Section's laboratory services in the Public Health Service Communicable Disease Center at Atlanta.

Visitors to U. S.

Sir Robert Watson-Watt, of London, spoke on the latest developments in defense radar at the recent annual meeting of the Institute of Radio Engineers in New York City.

Hans Selye, professor and director of the Institute of Experimental Medicine and Surgery at the University of Montreal, will deliver the seventh Frank Billings Lecture of the Institute of Medicine of Chicago at a joint meeting with the Chicago Medical Society on April 7, in the John B. Murphy Memorial Auditorium. His subject will be "The Diseases of Adaptation; With Special Reference to the Clinical Use of Corticoid Hormones."

Mateo H. Tupas, geologist with the Philippine Bureau of Mines, Manila; **Arne Ytrehus,** Department for Building Research, Royal Norwegian Council for Scientific and Industrial Research, Oslo; **L. Bugnard,** director de l'Institut National d'Hygiene, Paris; **Maoto Kameyama,** president of the Science Council of Japan and **Yoshio Nishina,** vice president of the same organization and president of the Scientific Research Institute, Tokyo, were recent visitors at the National Bureau of Standards.

Grants and Awards

The W. K. Kellogg Foundation of Battle Creek, Michigan has awarded $40,000 to the University of Illinois College of Dentistry in support of its postgraduate education program. The grant is for a three-year period and will be used to continue the school's telephone transmittal of lectures to dental societies and television broadcast of technical and surgical demonstrations.

The Catherine Wolfe Bruce Gold Medal for 1950 was presented to Alfred H. Joy, research associate at the California Institute of Technology and of the Carnegie Institution of Washington, at the March 17 meeting of the Astronomical Society of the Pacific. Dr. Joy was cited for his work in the field of stellar spectroscopy. He is the 20th American astronomer to receive the medal, which has also been awarded to 23 foreign astronomers.

The National Cancer Institute announced on March 7 the award of 22 Public Health Service grants, totaling $301,159, to aid cancer control projects. Of these, 15 were continuing grants. Seven new grants were awarded to the following institutions: Los Angeles County Hospital, Los Angeles, *Edward M. Butt,* $10,000 for a slide tumor library and registry; Association of American Medical Colleges, Chicago, *David S. Ruhe,* $3,748 for an evaluative study of existing cancer teaching films; Washington University, St. Louis, *Robert A. Moore,* $3,385 for health education, particularly cancer, in a large clinic; American Cancer Society, New York City, *Brewster S. Miller,* $2,233 for half of the development, production, and distribution costs of the *Proceedings of the National Cancer Conference*; trustees of the University of Pennsylvania, Philadelphia, *Cecilia Riegel,* $9,833 for the study of substances giving a reaction with tryptophane and an attempt to identify these substances; Meharry Medical College, Nashville, Tennessee, *G. J. Tarleton, Jr.,* $15,000 for radio-

therapy equipment to complete armamentarium of existing combined control, teaching, and research unit; and Washington University Medical School, St. Louis, *Robert Elman* and *Leo A. Sachar*, $13,154 for nutritional rehabilitation and metabolism in cases of advanced cancer.

Fellowships and Prizes

The Ministry of Public Health, Republic of Argentina, is offering 20 annual scholarships of 1,000 pesos for foreigners to study sanitation in Argentina. The one-year scholarships may be renewed. Knowledge of Spanish is necessary. Application blanks may be obtained from Educational Programs Branch, Division of International Health, U. S. Public Health Service, Washington, D. C.

The National Foundation for Infantile Paralysis is offering one-year fellowships to physicians, for study leading to a Master of Public Health degree at a school approved by the American Public Health Association. Candidates must be U. S. citizens, graduates of a class A medical school, must have completed an internship, and be licensed to practice medicine in one or more states. Financial benefits will be arranged according to needs of the individual. Each recipient must agree to work for two years as a public health officer in the U. S. or its territories. For further information write Professional Education Division, National Foundation for Infantile Paralysis, 120 Broadway, New York City.

The National Gastroenterological Association is offering $100 and a certificate of merit for the best unpublished paper on gastroenterology or allied subjects, the award to be made at the annual convention banquet of the association in October. Contestants in the U. S. must be members of the American Medical Association, and those from other countries must be members of a similar organization. Entries should be limited to 5,000 words, typewritten in English in manuscript form. Five copies must be submitted with an entry letter by *June 1* to National Gastroenterological Association, 1819 Broadway, New York City.

Colleges and Universities

The University of Wisconsin this month approved the integration of the Psychiatric Institute of its Medical School with the Mental Hygiene Division of the State Board of Public Welfare. A committee will be formed to maintain a close relationship between the school and the board in planning resident training in psychiatry, medical care and treatment of the mentally ill in county and state hospitals, and in promotion of mental health throughout the state. Leslie Osborn, head of the University of Buffalo Psychiatry Department, will direct the joint program beginning July 1. William F. Lorenz, present director of the institute, who is within a few years of the retirement age, will continue his work, related primarily to laboratory services of the institute.

The University of Chicago Institute for Nuclear Studies is developing a calendar to establish prehistoric dates in ancient Mexican civilizations by analyzing the amounts of radioactive carbon 14 in samples of wood, plants, and charcoal. The samples were brought from Mexican archaeological sites by Helmut de Terra, research associate of the Viking Fund. Analysis will be made by W. F. Libby and James R. Arnold, of the Chemistry Department, and their collaborators, who developed the method of determining ancient dates by checking the amount of carbon 14 in remains of once living organisms (*Science*, March 4, 1949, p. 227).

Summer Programs

Two workshops in the visual sciences will be offered during the summer by the Southern College of Optometry, Memphis, Tennessee. The seminar for practising optometrists will be held July 17–28. It will deal with psychological optics, the diagnosis and remediation of reading difficulties involving visual malfunction, illumination and seeing, and optometric procedures and techniques required to fit contact lenses. The seminar for teachers will present information about the vision of children of school age, the improvement of the classroom environment by controlling light and other factors affecting vision, and the teaching of reading, with particular attention to disabled readers. Address inquiries to E. W. Taylor, Southern College of Optometry, 865 Washington Avenue, Memphis, Tennessee.

The University of Oklahoma has established a new biological station on Lake Texoma near Willis, Oklahoma. The first annual summer session will be held July 1–August 26. Both graduate and undergraduate courses in botany and zoology will be given, as well as research courses. Admission forms or additional information may be obtained from Carl D. Riggs, Director of the University of Oklahoma Biological Station, Norman, Oklahoma.

Meetings and Elections

The Pacific Northwest Regional Meeting of the American Chemical Society will be held at Richland, Washington, June 9 and 10, under joint sponsorship of the Puget Sound, Oregon, Washington-Idaho Border, and Richlands sections of the ACS. This meeting is the first to be held in the government-owned community constructed for the employees of the Hanford Plutonium plant.

The Division of High Polymer Physics of the American Physical Society has elected the following officers to its executive committee for 1950: chairman W. L. Davidson of the B. F. Goodrich Research Center; vice chairman, J. Barton Nichols, E. I. duPont de Nemours and Company; secretary, W. James Lyons, Firestone Tire and Rubber Company; and treasurer, J. W. Liska, also of Firestone Tire and Rubber Company.

The second meeting of the **Committee of Electrochemical Thermodynamics and Kinetics** will be held September 18–21 at Milan and Pallanza, Italy. Inquiries may be addressed to Roberto Piontelli, Milan Politecnico, to P. Van Rysselberghe, University of Oregon, Eugene, Oregon, or to Marcel Pourbaix, University of Brussels, Belgium.

Native Arts of the Pacific Northwest, the first volume in the Stanford University Art Series, is a picture-and-prose record of northwestern Eskimo and Indian culture. It had its origin in a collection made over a period of a quarter-century by Axel Rasmussen, an Alaskan superintendent of schools who, as a friend of the Indians, was given artifacts discovered in old burial sites and even totemic objects and fetishes that natives seldom relinquish. He died before his plans for a Skagway Museum could be completed, but his notes, which reveal equal interest in anthropology and aesthetics, were used in writing the text that accompanies the photographs, many of them in color, of 200-odd art objects.

The Portland Art Association acquired the Rasmussen collection from Earl Stendahl, of Los Angeles, who brought it down from Alaska. It comprises 5,000 articles, some of which are on display at the Portland Art Museum, the remainder being reserved as a study collection. The art objects, made of wood, horn, bone, and other raw materials found along the coast, are alive and charming.

The book was designed by Alvin Lustig and the photographs were made by William Reagh. Robert Tyler Davis, director of Montreal's Museum of Fine Arts and professor at McGill University, wrote the introductory text. The American Institute of Graphic Arts has chosen the volume as one of the fifty best books of 1949.

The Iranian government will have the assistance of three U. S. Public Health Service officers in developing a public health service in that country. Emil E. Palmquist, medical officer in charge of the project, Frederick F. Aldridge, sanitary engineer, and Esther M. Finley, public health nurse, will aid in establishing public health training programs, initiate health demonstrations, and serve in an advisory capacity to the government. The team, organized by the USPHS Division of International Health, will also assist in recruiting Iranian nationals for public health training abroad.

The National Bureau of Standards announced early this month the development of a National Neutron Standard. The standard is a primary neutron source which can be used to calibrate neutron-measuring instruments, to measure accurately the radiation of neutron-emitting substances, and to prepare secondary standards for distribution to industry and laboratories.

A new edition (Form Z) of the ACS Cooperative Test in Biochemistry is being published and will be released for sale April 15. The results can be used to grade students in a class, to compare the achievement of students in one institution with that of students in other institutions, and to determine the degree of preparation in biochemistry of students entering medical and dental schools.

Copies of the test and of the answer sheets which must be used in conjunction with it can be obtained from the Cooperative Test Division of the Educational Testing Service, 20 Nassau Street, Princeton, New Jersey. Sample copies are available on request.

A research clinic to investigate multiple sclerosis and related disorders was opened March 13, with headquarters at Bellevue Hospital in New York City. The new clinic was made possible by a grant of over $100,000 from the National Multiple Sclerosis Society to New York University Post-Graduate Medical School, and will be staffed by members of the school's faculty. S. Bernard Wortis is administrator of the clinic, Morris Bender is supervisor, and Morton Nathanson is medical director.

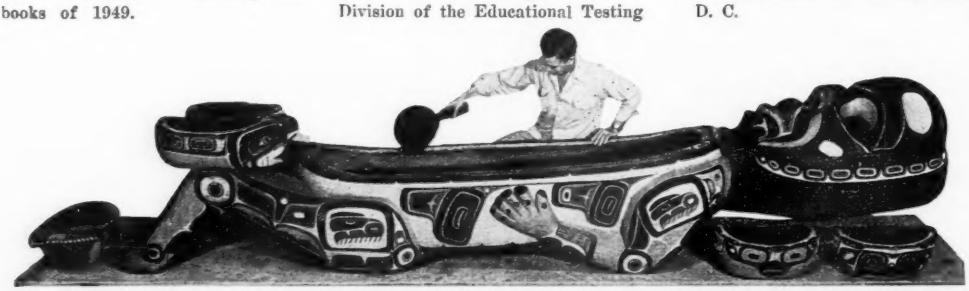
Recently Received—

Heating in Stored Wheat. Council for Scientific and Industrial Research Bull. 237. Commonwealth of Australia, 314 Albert St., East Melbourne, C.2, Victoria.

A Note on Some Scientific Studies Undertaken by Members of the Colonial Medical Service, 1930–47, with Bibliography. Colonial Office Bull. 252. Colonial Office Information Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

List of Scientific Papers Published in the Middle-East, Nov. 1949. Unesco Publ. Moyen-Orient Science Cooperation Office, Middle-East, 8 Sh. El Salamlik, Garden City, Cairo, Egypt.

The Roll Call of the Iroquois Chiefs: A Study of a Mnemonic Cane from the Six Nations Reserve. William N. Fenton. Publ. 3995, Smithsonian Institution, Washington 25, D. C.



POTLATCH FOOD DISH representing a human figure. The mask at the top of page forms a cover for the head. This represents work of the Kwakiutl tribe, which lived along the shores of the islands, straits, and inlets of the area from Vancouver Island north to the mainland of Alaska. Reproduced from *Native Arts of the Pacific Northwest,* Stanford University Press, Stanford, California, 1949, $7.50.

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New Books of Interest

BOTANY

An Introduction to Plant Science. By W. W. ROBBINS and T. E. WEIER, *both at the University of California.* Covers the basic facts of plant science and their relation to agriculture, medicine, and many other fields. The authors review recent discoveries in plant anatomy, photosynthesis, respiration, genetics, water relations, growth substances, chromosome structure, and many other subjects. *Ready in April. 479 pages. 490 illus. Prob. $5.00.*

HETEROCYCLIC COMPOUNDS

Volume I. Edited by R. C. ELDERFIELD, *Columbia University.* Deals with the chemistry of monocyclic heterocycles containing one oxygen, sulfur, and nitrogen atom. The authors offer the latest information on these compounds plus a critical evaluation of the published data. Stress is on the chemical principles involved in the syntheses and reactions. Complete references are given. *Ready in April. 703 pages. $11.00.*

APPLIED SEDIMENTATION

A Symposium. Edited by PARKER D. TRASK, *State of California Department of Public Works.* This new handbook contains 35 original articles prepared by specialists in the fields of geology and engineering. Articles are grouped under: basic principles of sedimentation; engineering problems involving strength of sediments; applications of processes of sedimentation; applications involving nature of constituents; economic mineral deposits; petroleum geology problems; military applications. *Ready in March. 707 pages. $5.00.*

BIOLOGY of DROSOPHILA

Edited by M. DEMEREC. *Carnegie Institution of Washington.* Treats in detail the anatomy, histology, and development of Drosophila. The basic norm is presented as a standard for the analysis of experimentally induced genetic variation and for other physiological studies. Methods of collecting, shipping, culturing, feeding, and other laboratory techniques are described in detail. *Ready in May. Approx. 600 pages. 251 illus. Prob. $10.00.*

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OUTSTANDING BOOKS IN CHEMISTRY

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PHYSICAL

Scientific Foundations of Vacuum Technique. By Saul Dushman. 1949. 882 pages. 328 illus. $15.00.

Introduction to Radiochemistry. By Gerhart Friedlander and Joseph W. Kennedy. 1949. 412 pages. Illus. $5.00.

The Structure of Matter. By Francis Owen Rice and Edward Teller. A book in the Structure of Matter Series, Maria Goeppert Mayer, Advisory Editor. 1949. 361 pages. Illus. $5.00.

Trilinear Chart of Nuclear Species. Prepared under the direction of William H. Sullivan. 1949. $2.50.

Radioactive Measurements with Nuclear Emulsions. By Herman Yagoda. 1949. 356 pages. Illus. $5.00.

Outlines of Physical Chemistry. By Farrington Daniels. 1948. 713 pages. $5.00.

Vacuum Manipulation of Volatile Compounds. By R. T. Sanderson. 1948. 162 pages. Illus. $3.00

The Electronic Theory of Acids and Bases. By W. F. Luder and Saverio Zuffanti. 1946. 165 pages. $3.00.

PHYSIOLOGICAL

The Chemistry of Industrial Toxicology. By Hervey B. Elkins. 1950. 406 pages. Illus. $5.50.

Biochemical Preparations. Volume I. Editor-in-Chief: Herbert E. Carter. 1949. 76 pages. $2.50.

Outlines of Biochemistry. Third Edition. By the late Ross Aiken Gortner. Third Edition edited by Ross Aiken Gortner, Jr., and Willis Alway Gortner. 1949. 1078 pages. Illus. $7.50.

Essentials of Physiological Chemistry. Third Edition. By Arthur K. Anderson. 1947. 395 pages. Illus. $3.50.

Bacterial Chemistry and Physiology. By J. R. Porter. 1946. 1073 pages. Illus. $12.00.

ANALYTICAL

Quantitative Ultramicroanalysis. By Paul L. Kirk. 1950. 310 pages. 113 illus. $5.00.

Quantitative Analysis. Third Edition. By W. C. Pierce and Edward L. Haenisch. 1948. 520 pages. Illus. $3.75.

Fundamentals of Semi-Micro Qualitative Analysis. By Carl J. Engelder. 1947. 385 pages. $3.50.

Qualitative Organic Microanalysis. By Frank Schneider. 1946. 218 pages. 135 illus. $3.50.

COLLOID

Colloid Chemistry. Second Edition. By Harry Boyer Weiser. 1949. 444 pages. Illus. $5.50.

GENERAL

An Introduction to Chemical Science. Second Edition. By W. H. Hatcher. 1949. 449 pages. Illus. $4.00.

Fundamental Chemistry. Second Edition. By H. G. Deming. 1947. 745 pages. Illus. $4.00.

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Organic Reactions. Volume V. Editor-in-Chief: Roger Adams. 1949. 446 pages. $6.00.

Isotopic Carbon. Techniques in Its Measurement and Chemical Manipulation. By Melvin Calvin, Charles Heidelberger, James C. Reid, Bert M. Tolbert, and Peter E. Yankwich. 1949. 376 pages. 115 illus. $5.50.

The Chemistry of Organic Medicinal Products. Third Edition. By Glenn L. Jenkins and Walter H. Hartung. 1949. 745 pages. Illus. $7.50.

Principles and Practice in Organic Chemistry. By Howard J. Lucas and David Pressman. 1949. 557 pages. Illus. $6.00.

Organic Syntheses. Volume 29. Edited by Cliff S. Hamilton. 1949. 119 pages. $2.50.

Electronic Interpretations of Organic Chemistry. Second Edition. By A. Edward Remick. 1949. 600 pages. Illus. $6.00.

Quantitative Organic Analysis via Functional Groups. By Sidney Siggia. 1949. 152 pages. Illus. $3.00.

Advanced Organic Chemistry. Second Edition. By G. W. Wheland. 1949. 799 pages. Illus. $8.00.

Organic Reactions. Volume IV. Editor-in-Chief: Roger Adams. 1948. 428 pages. $6.00.

An Introduction to Organic Chemistry. Third Edition. By Ira D. Garard. 1948. 396 pages. Illus. $3.50.

The Preparation, Properties, Chemical Behavior, and Identification of Organic Chlorine Compounds. By Ernest Hamlin Huntress. 1948. 1443 pages. $27.50.

Organic Syntheses. Volume 28. Edited by Harold R. Snyder. 1948. 121 pages. $2.50.

Fatty Acids and Their Derivatives. By the late A. W. Ralston. 1948. 986 pages. Illus. $10.00.

The Systematic Identification of Organic Compounds. Third Edition. By Ralph L. Shriner and Reynold C. Fuson. 1948. 370 pages. Illus. $4.00.

A Brief Course in Organic Chemistry. First Edition, Revised. By Reynold C. Fuson, Ralph Connor, Charles C. Price, and Harold R. Snyder. 1947. 267 pages. Illus. $3.00.

Organic Syntheses. Volume 27. Edited by Ralph L. Shriner. 1947. 121 pages. $2.25.

Organic Reactions. Volume III. Editor-in-Chief: Roger Adams. 1946. 461 pages. $6.00.

Organic Syntheses. Volume 26. Edited by Homer Adkins. 1946. 124 pages. $2.25.

Introduction to the Chemistry of the Silicones. By Eugene G. Rochow. 1946. 137 pages. $2.75.

INORGANIC

Boron Trifluoride and Its Derivatives. By Harold Simmons Booth and Donald Ray Martin. 1949. 315 pages. Illus. $5.00.

The Rare-earth Elements and Their Compounds. By Don M. Yost, the late Horace Russell, Jr., and Clifford S. Garner. 1947. 92 pages. $2.50.

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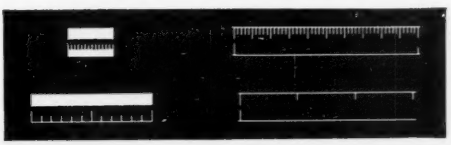

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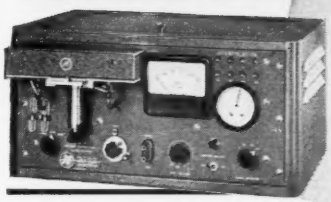

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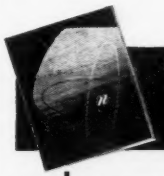

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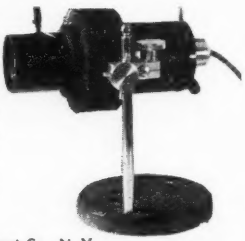

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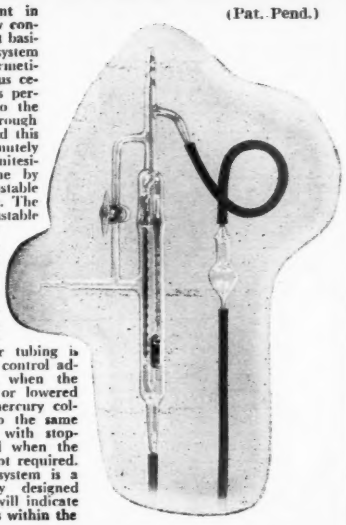

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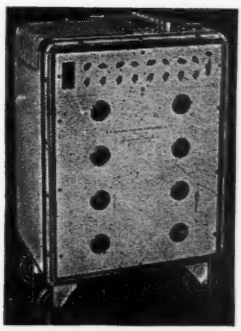

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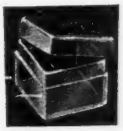

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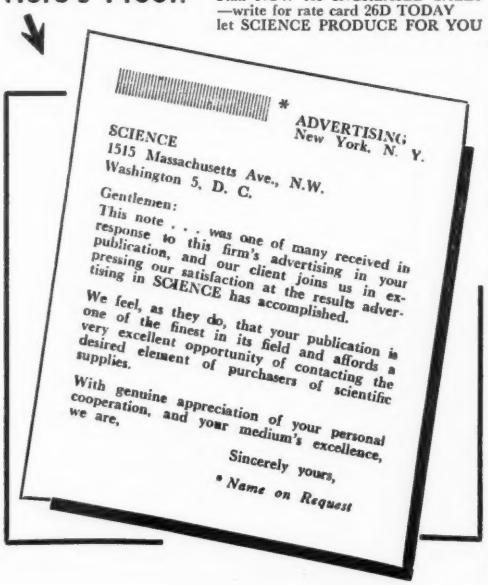

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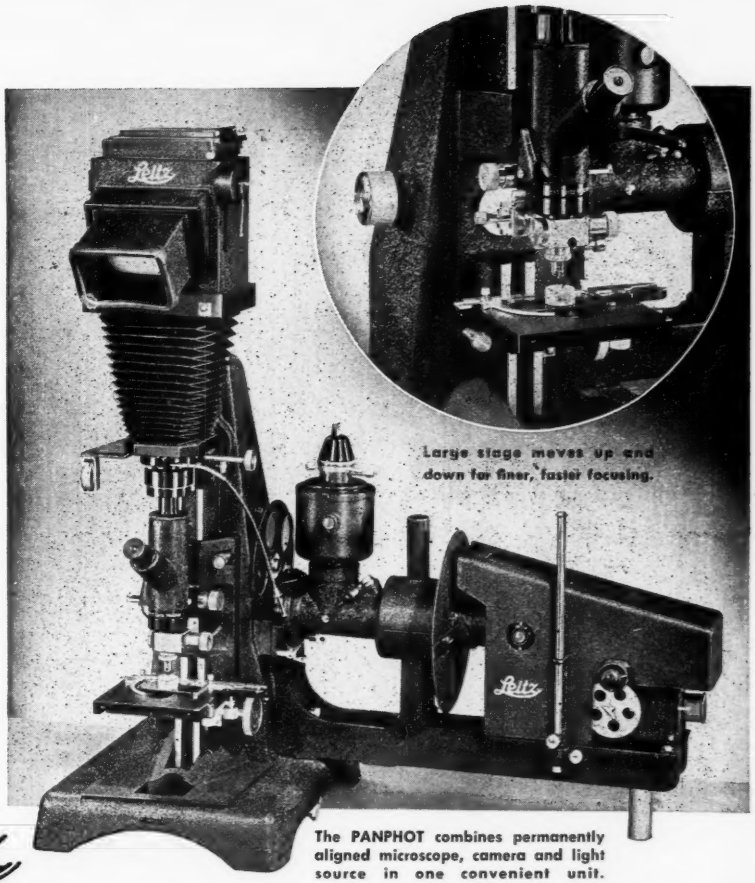

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Easy observation of the image to be photographed is provided by a large ground glass in the reflex mirror camera. The camera accommodates 3¼" x 4¼" plates or cut film for black and white or color work.

A full range of accessories is available to equip the PANPHOT for every phase of photo-micrography, photo-macrography and for drawing and projecting micro-images.

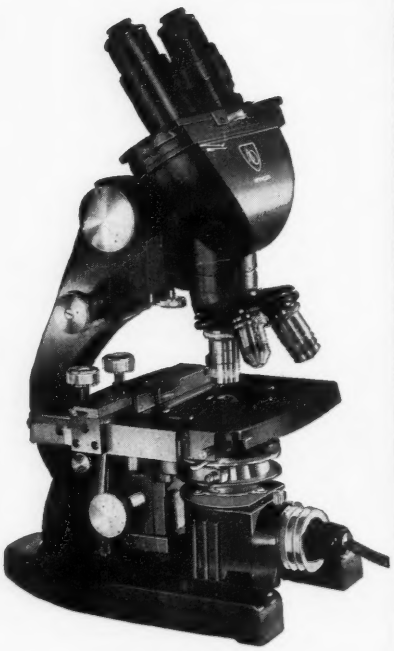
Write today for information to Dept. SC

E. LEITZ, Inc., 304 Hudson Street, New York 13, N. Y.

LEITZ MICROSCOPES • SCIENTIFIC INSTRUMENTS • LEICA CAMERAS AND ACCESSORIES

Save Time with "AUTOFOCUS"

in your new AO Spencer Microscope



HOW TO USE AUTOFOCUS

FOR FIRST SLIDE

1 With coarse adjustment, rack down 10X or 43X objective to the stop.

2 Critically focus with fine adjustment.

MICROSCOPE IS NOW IN AUTOFOCUS FOR ALL OBJECTIVES

TO USE OIL IMMERSION OBJECTIVE

3 Rack up the coarse adjustment and place a drop of oil on the slide.

4 Rack down coarse adjustment to stop.

MICROSCOPE IS IN OIL CONTACT AND STILL IN FOCUS—subject to minor corrections with fine adjustment due to thickness of specimen.

"Autofocus" is made possible by a unique focusing stop built into the *new* AO Spencer Microscopes. The stop also makes it impossible to rack the objective into the condenser. For further information about the many advantages of these new microscopes, write Dept. C4.

American AO Optical COMPANY

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